RADC-TR-61-243

28 August 1961

TECHNICAL REPORT

TRAILER VAN V138 ( )/M

DESIGNED & DEVELOPED

BY

CRAIG SYSTEMS, INC.

LAWRENCE, MASS.

REPORT NO. 117

CONTRACT NO. AF30 (602) - 1943

PROJECT NO. 4517

TASK NO. 45414

PREPARED FOR

ROME AIR DEVELOPMENT CENTER

AIR FORCE SYSTEMS COMMAND

GRIFFISS AIR FORCE BASE

NEW YORK

NOTICES

This report has been released to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D.C., for sale to the general public.

1.0 ABSTRACT

1.0 This document presents the final technical report under Contract No. AF30(602)-1943 for a tandem axle trailer van prototype to house Mobile Electronic Communication equipment. The report covers investigations and analysis in the areas of road stability, weight distributions, structural integrity and handling of sub-assemblies. The report also includes a list of drawings of the major components and pictures of the Prototype V138( )/M Trailer Van.

2.0 INTRODUCTION

2.1 RADC Exhibit

2.1.1 The Rome Air Development Center issued an invitation for bids on the design, fabrication and testing of a service test model of trailer Van V-138( )/M in accordance with Rome Air Development Center Exhibit RADC-5022 date 17 March 1958. (See Reference I) The purpose of the trailer was to be used as a service test model for electronics and associated equipment. The trailer was to consist of a van and removable trailer chassis. The van was to be made into two parts consisting of a "platform" and "detachable top assembly." The trailer van was required to have a gross weight of no more than 8,000 lbs. and to carry a payload of 4,000 lbs.

2.2 Craig Systems, Inc. Proposal

2.2.1 Craig Systems, Inc. of Lawrence, Mass. submitted a proposal, (BR No. 1368 dated 21 April 1958) (Reference II) containing an engineering approach they would expect to make toward the supply of the Trailer Van V-138( )/M. Craig proposed to supply the V-138 as much like Trailer Van V-83/M as practicable because of the great similarity between the two trailers. Since Craig designed, developed and was manufacturing the V-83, it was considered that a wealth of design information and experience were available to meet the requirements of the V-138. The differences between the two trailers lie essentially in the following:

1. The trailer van would be separable into three main components: Trailer Chassis, Platform, and Detachable Top Assembly so that each of the three major components could be helicopter lifted separately.

2. The platform would be made lighter than in the V-83 so that the combined weight of the platform and the maximum facility payload would come within the limited capacity of the H-21 helicopter.

3. The electrical power junction box and the power distribution cabinet would be mounted on the platform so that the payload could be powered while the Detachable Top Assembly is removed from the platform.

4. A forced air ventilation system would be included in the Detachable Top Assembly and no air conditioner ports would be provided.

5. Transportation by air would be by the C-123 instead of the C-119 aircraft.

Craig also submitted a supplement to their proposal dated 26 April 1958 (Reference III) indicating that although the V-83 and V-138 may be similar, the detailed design would be entirely open to investigation, study, and improvement.

2.2.2 The Van was to be essentially a rectangular shaped structure having insulated walk, floor and roof. The "DTA" was to be easily attached or separated from the "platform". The internal dimensions of the vans were to be 7 ft. - 8 in. in width by 6 ft. - 6 in. in height by 11 ft. - 8 in. in length.

2.2.3 The Detachable Top Assembly was to be constructed of a lightweight, stressed skin sandwich material. It was to be equipped with lifting eyes capable of lifting the DTA or when attached to the platform lifting the entire trailer van. It was also to be equipped with jack mounting plates for removal from the platform.

2.2.4 The platform was to be designed to support a uniformly distributed load of 250 pounds per square foot and concentrated load of 300 pounds and to be of stressed skin sandwich construction reinforced to accommodate the loads introduced from equipment installed when transported by helicopter, air, rail, vehicle and water shipment. It was to be a unit so that when used alone, without the undercarriage or DTA, with equipment mounted thereon, it could be operated in the worst possible combination of service conditions. The platform was to be equipped with lifting eyes and its weight should not have exceeded 500 pounds.

2.2.5 The undercarriage was to be designed to have similar characteristics to the V-83 Trailer Van. A study was to be made of various types suspension systems, and a review of the stability of the vehicle and the possible use of surge brake system made. The undercarriage was to be equipped with a single draw-bar, box beam type, hinged or removable for minimum cubage when stored transported.

2.3 Contract Award

1.3.1 The Rome Air Development Center, after consideration of the various proposals made by a number of manufacturers, awarded Craig Systems, Inc. the contract to design, develop, and fabricate one field service trailer V-138( )/M based upon their proposal and exhibit. Upon award of the contract Craig initiated a development program supported by experimental tests and stress analysis of the trailer.

3.0 DISCUSSION

3.1 Preliminary Trailer Stability Study

3.1.1 A study was made to determine what type of trailer would provide the best stability with rigidity comparable to the V-83 trailer. For this study two types of trailers were considered, one consisting of a tandem axle trailer equipped with leaf springs, the other was a trailer equipped with dual wheels and individual coil spring suspension. Both trailers were considered to have equivalent gross weights, heights of C.G., wheel tread widths, and spring rates. The spring rates used were similar to that of the V-83 trailer. This study determined that the tandem axle trailer would have approximately 19 per cent greater stability than the dual wheeled trailer. (See Reference I). The final design incorporated the tandem axle configuration.

3.2 Static Load Tests

Tests were conducted on each of two panels to determine the uniform load which the panels would satisfactorily support with no permanent deformation (See Reference II).

3.2.1 The first panel tested was 4 ft. x 8 ft. using 4#/ft^3 foamed in place polyurethane foam and .032 6061-T6 aluminum skin on one side only and framed in a hollow rectangular aluminum extrusion.

3.2.2. The second panel tested was the test sample used in 3.2.1 except that another .032 6061-T6 aluminum skin was bonded to the opposite face.

3.2.3 The double aluminum skin construction as described in paragraph 3.2.2 was adopted for the basic van panel design.

3.3 Mounting Racks for Test Weights

3.3.1 A study was made of the design and strength of the mounting racks for the tests weights to be attached to the platform (See Reference III).

3.3.2 It is to be noted that, although this study was made, the racks were not used for testing because of lack of funds. It was agreed with the cognizant RADC Engineer that tests could be performed using sand bags.

3.4 Preliminary Calculation of Center of Gravity of the Van

3.4.1 Calculations were made to determine the location of the center of gravity of the van consisting of the platform and detachable top assembly (See Reference IV).

3.4.2 The purpose of these calculations was to obtain criteria for handling of the van and for possible future design of handling equipment.

3.5 Lifting Rig

3.5.1 At the request of the cognizant RADC engineer a design investigation only was made for a lifting sling for handling the platform assy. (See Reference V).

3.6 Illustrations

3.6.1 The illustrations on the following page depict the prototype Trailer Van V-138( )/M as manufactured by Craig Systems, Inc. Figure I (Craig Systems Photo 1670-4) is the rear view and clearly indicates the three major components, the trailer chassis assembly, the platform assembly of the van, and the detachable top assembly of the van. Figure II (Craig Systems Photo 1670-2) is the front view and in addition shows the jacks in their stored positions.

3.6.2 In addition, Craig Systems Inc., Drawing D15547 revised to level C to include pertinent reference dimensions has been included in the report.

FIGURE I
REAR VIEW TRAILER VAN V-138( )/M
CRAIG SYSTEMS INC. PHOTO NO.1670-4

FIGURE II
FRONT VIEW TRAILER VAN V-138( )/M
CRAIG SYSTEMS INC. PHOTO NO. 1670-2

4.0

REFERENCES

4.0

REFERENCES

I Exhibit RADC-5022 dated 17 March 1958

II Craig Systems Inc., Proposal (BR No. 1368 dated 21 April 1958)

III Craig Supplement Proposal (BR No. 1368 dated 26 April 1958).

IV Craig Systems, Inc., Drawings

- D15547 G1 - Trailer Van V-138( )/M
- R15198 G1 - Interior Assembly
- 83D616 - Cable - Intervehicular
- R14919 G1 - Platform Assembly Van V-138( )/M
- R15078 G1 - Detachable Top Assembly Van V-138 ( )/M
- D15008 - Chassis, Trailer V138( )/M
- D15200 - Jack Assembly, Left
- D15201 - Jack Assembly, Right

5.0

APPENDICES

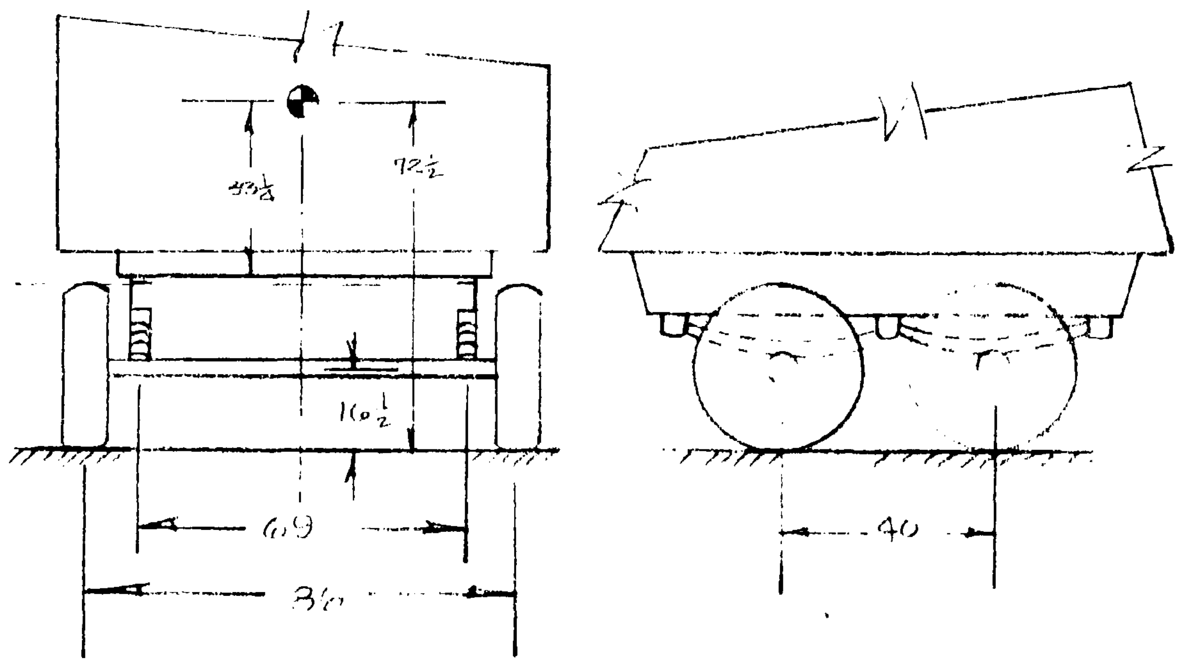
I	Preliminary Trailer Stability Study
II	Static Load Tests
III	Mounting Racks for Test Weights
IV	Preliminary Calculation of Center of Gravity of Van
V	Lifting Rig
VI	Craig Systems Inc. drawing D15547 Rev. C.

APPENDIX I

PRELIMINARY TRAILER STABILITY STUDY

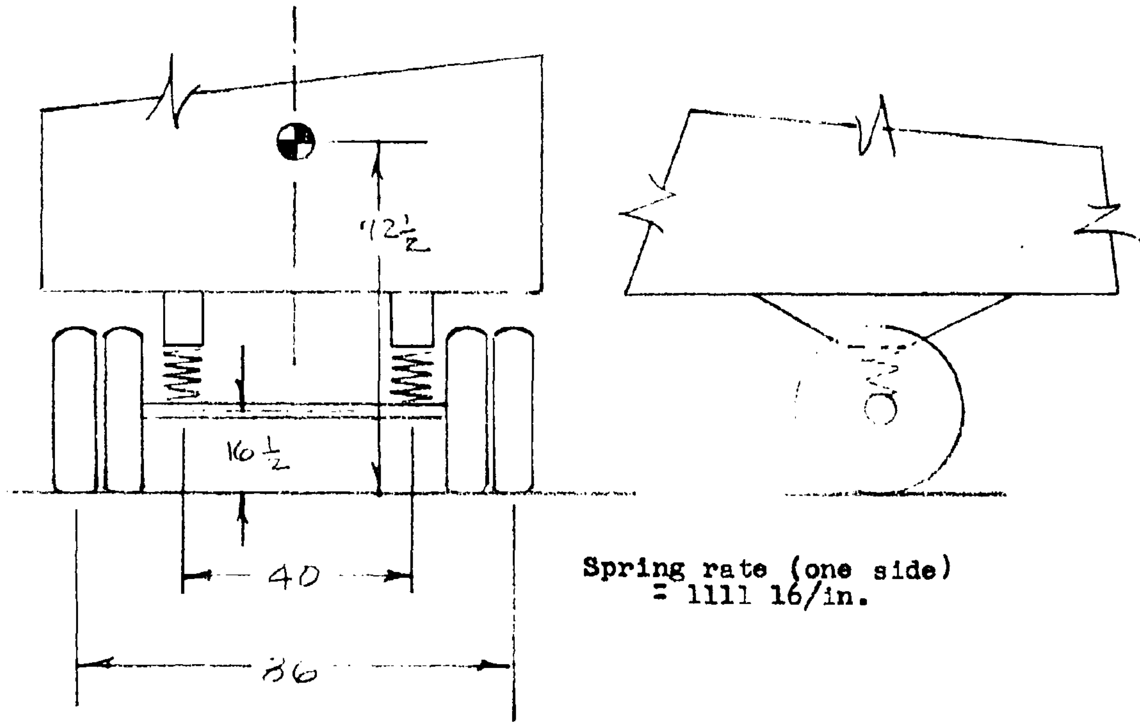
Basis of Comparison:
Case I: Running gear with tandem axles, four single wheels, and four leaf springs.

Case II: Running gear with single axle, two dual wheels, and two coil springs.



Spring rate (One side) = 694 #/in.

CASE I



Spring rate (one side)
= 1111 lb/in.

CASE II

CONSTANTS

W = Sprung Weight:

= 6450 lb. for Case I

= 6850 lb. for Case II

W^1= Sprung Weight

= 1250 lb. for Case I

= 850 lb. for Case II

B = Track distance = 86 inches

b = Spring distance

= 69 inches for Case I

= 40 inches for Case II

a = Axle height = 16.5 inches

h = Verbical distance between axis of sway and C.G. of van

= 39.5 inches for Case I

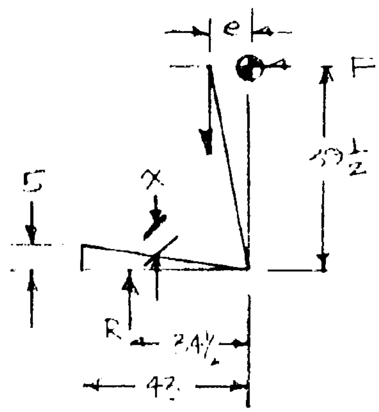
= 56 inches for Case II

K = Spring constant

= 694 lb/in. for Case I (one side)

= 1111 lb/in. for Case II (one side)

CASE I: Due to the high lateral rigidity of the leaf springs, we may assume that the van sways about a point on the center line at about the height of the taps of the tires:



Let e = Lateral shift of C.G.

x = Deflection of spring

F = Lateral force

To cause shift "e".

R = Force in

Spring caused by deflection "x".

Hence $e = 5 \times \frac{39.5}{43} = 4.60$

and $x = 5 \times \frac{34.5}{43} = 4.00$

$R = 4 \times 694 = 2775$ lb.

$F = \frac{2R \times 34.5 - 6700 \times 4.6}{39.5} = 4080$ lb.

which is the force required to tilt the Van to a point where the floor touches the wheel.

It is shown on page 10 that the condition for speed is expressed by the following equations:

$$1 \qquad F = \frac{\frac{1}{2}B\,(W + W^1)}{W\left[\dfrac{2h^2}{Kb^2 - 2HW}\right]} + a\,\frac{W^1}{W} + H$$

$$2 \qquad e = F\left[\frac{2h^2}{Kb^2 - 2hW}\right]$$

Where H = Vertical height ground to C.G. van.

e = Shift of C.G. of van

F = Force required to upset trailer

h = height, pivot point to CG of van

b = distance between springs

W = Sprung Weight

W^1 = unsprung weight

K = spring constant

B = Track

a = axle height,

assuming no bottom-out or wheel-touch.

So in our case:

$$F = \frac{43\,[7700]}{6450\left[\dfrac{2(39.5)^2}{694\,(69)^2 - 2(39.5)6450}\right]} + 3.2 + 72.5$$

$$F = \frac{331{,}000}{6450\left[\dfrac{3120}{3{,}305{,}000 - 510{,}000}\right]} + 75.7$$

$$F = \frac{331{,}000}{6450\left[\frac{3120}{2{,}795{,}000}\right] + 75.7}$$

F = 3997 lbs.

$$e = 3997\left[\frac{3120}{2{,}795{,}000}\right] = 4.5 \text{ inches,}$$

So upset occurs before van touches wheel.

$$v\ (\text{upset}) = \sqrt{\frac{Fgr}{W}}$$

$$= \sqrt{\frac{3997 \times 32 \times 100}{6450}} \text{ (For 100 ft turning radius)}$$

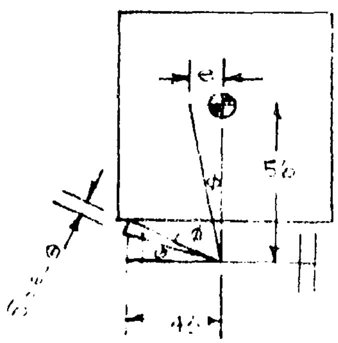
$$= \sqrt{1984}$$

$$= 44.5 \text{ ft. sec.}$$

$$v\ (\text{upset}) = \underline{30.4 \text{ miles/hour}}$$

CASE II:

Due to the configuration of the running gear, assume the axis of sway is on the centerline at axle height.



$$\frac{e}{56} = \frac{5 \text{ Sec } \theta}{43 \text{ Sec } \theta}$$

or e = 6.51 inches, when the wheel touches the van.

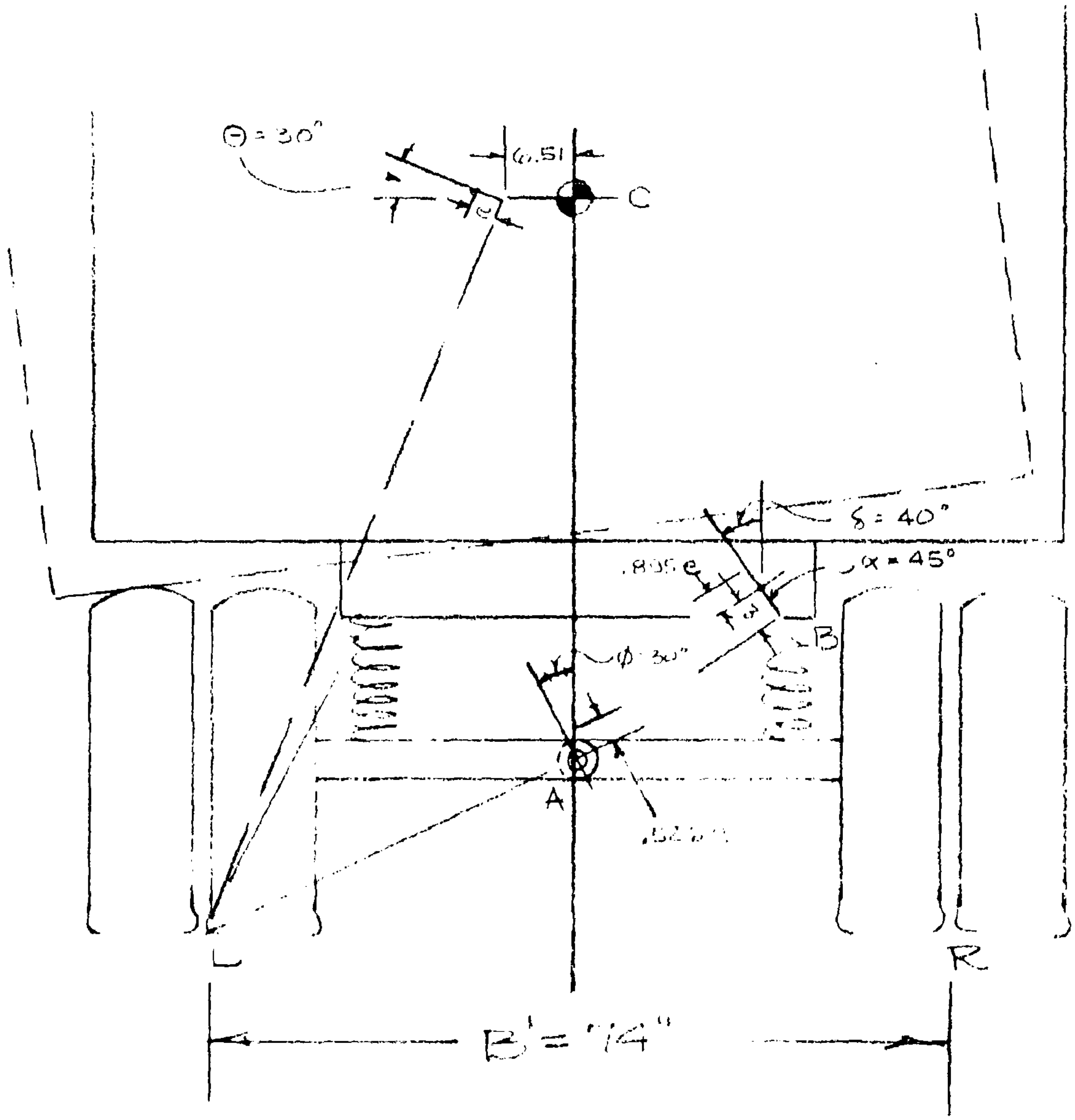
Upon the application of a gradually increasing centrifugal force "F" at the C.G. of the van, and from the geometry of Case II it can be verified that points A, B, and C move as shown on the sketch on the following page, and this is accomplished in two cycles:

(1) As point C moves 6.51 "horizontally to the left, points B and D move 3" diagonally upward and downward, respectively, and point A remains motionless.

(2) The left spring bottoms, the van and left side of the running gear rotate as a unit about point L, and points A, B, and C move as follows:

Point A - a distance .526 @ about 30° from vertical
Point B - a distance .895 @ about 40° from vertical
Point C - a distance e @ about 30° from horizontal,

at which time, assume the van is about to upset, i.e. The reaction at "R" is zero.

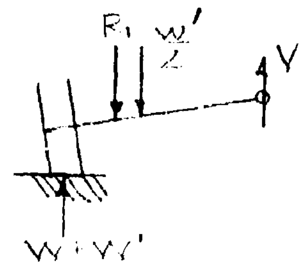


Θ = 30°
6.51
e
C
δ = 40°
α = 45°
.805 e
e
B
φ = 30°
A
L
R
B' = 74"

We must solve for the value of "e" at upset, and for the upsetting force "F".

Considering the left side of the running gear as a free body, noting that the reaction at "L" must be $W + W1$, and assuming an upward vertical force "V" at the knee pin, we may say :

$$\sum F_y = 0: \ (W + W^1) + V = \frac{W1}{2} + R_1$$



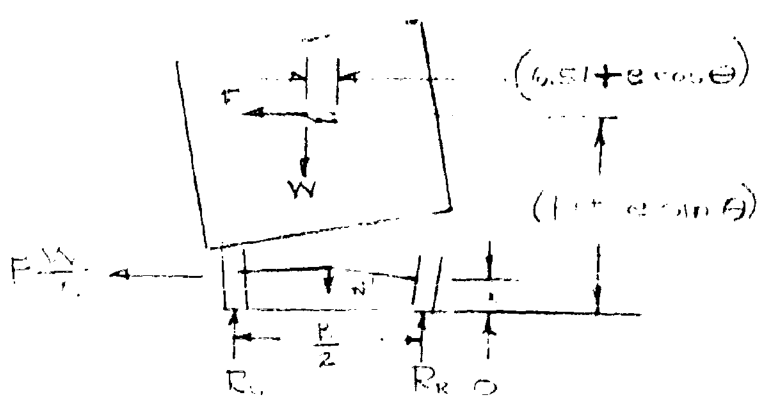
Considering the right hand spring, we may set down its total upward reaction on the sprung weight.

$$R_2 = \frac{W}{2} - K\,(3 \cos. \alpha + .895\ e \cos \delta)$$

$$= 3425 - 1111 \left[3 \times .707 + .895 \times .69 \times e\right]$$

or $R2 = 1065 - 766e$

Now considering the van as a free body:



$$\sum M_L = 0: \quad F\left[H + e \sin \Theta\right] + F \frac{W^1}{W} a = \frac{B^1}{2} W^1 + \left[\frac{B^1}{2} - 6.51 - e \cos. \Theta\right] W.$$

Substituting and solving for F, we get

$$F = 3025 \text{ lbs.}$$

$$v = \sqrt{\frac{Fgr}{W}} = \sqrt{\frac{3025 \times 32 \times 100}{6850}}$$

$$= 37.6 \ \frac{\text{ft.}}{\text{Sec.}}$$

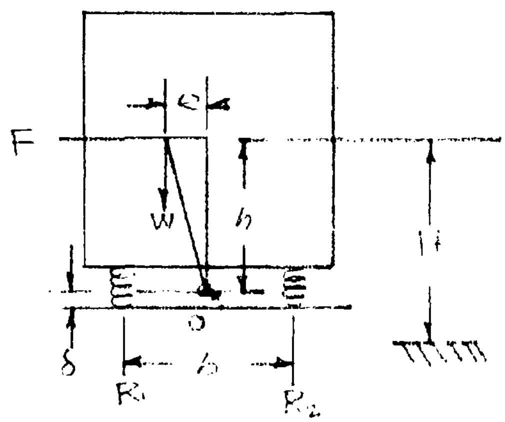
$$= 25.6 \text{ m.p.h.}$$

Percentage greater stability of Case I over Case II:

$$\frac{30.4 - 25.6}{25.6} = 19\%$$

Conclusion: For equal softness of ride, we have 19% greater stability in Case I.

Development of Equations for Upsetting Condition of Trailer



Consider the sprung weight as a free body:

Take moments about left spring

$$R_2 b + Fh = W\left(\frac{b}{2} - e\right)$$

$$\text{or } R_2 = \frac{W}{2} - \left[\frac{We + Fh}{b}\right]$$

$$R_1 = W - R_2$$

$$= \frac{W}{2} + \left[\frac{We + Fh}{b}\right]$$

Before the application of "F",

$$R_1 = R_2 = \frac{W}{2}$$

$$\text{So } \Delta R_1 = + \frac{We + Fh}{b}$$

$$\text{and } \Delta R_2 = - \frac{We + Fh}{b}$$

Let "K" be the spring constant. Then

$$\delta K = \frac{We + Fh}{b}$$

$$\text{or } \delta = \frac{1}{K}\left[\frac{We + Fh}{b}\right]$$

Also $\frac{e}{h} = \frac{\delta}{\frac{1}{2}b}$ or $e = \frac{2\delta h}{b}$

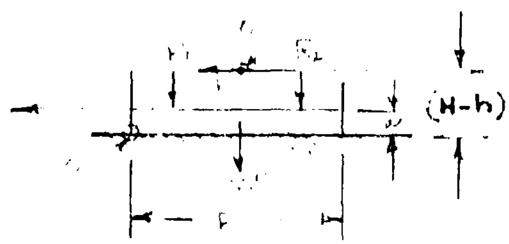
Substituting: $e = 2h \; \frac{We + Fh}{Kb^2}$

$$ekb^2 - e2HW = 2FH^2$$

$$e = \frac{2Fh^2}{Kb^2 - 2hW}$$

$$\text{OR } \boxed{e = F \; \frac{2h^2}{Kb^2 - 2hW}}$$

Now consider the unsprung weight as a free body:



Take moments about "O":

$$\frac{B}{2} W^1 + R_1\left[\frac{B-b}{2}\right] + R_2\left[\frac{B + b}{2}\right] = (H-h)\ F + a\ \frac{W^1}{W}\ F$$

Substitute in the previous values for R_1 and R_2:

$$\frac{B}{2} W^1 + R_1 \left(\frac{W}{2} + \frac{We + Fh}{b}\right)\left(\frac{B-b}{2}\right)$$

$$+ \left(\frac{W}{2} - \frac{We + Fh}{b}\right)\left(\frac{B + b}{2}\right) = F\left[H-h + a\ \frac{W^1}{W}\right]$$

This reduces to

$$\frac{B}{2}(W + W^1) - We - Fh = Fh + F\left[H + a\frac{W^1}{W}\right]$$

$$F\left[H + a\frac{W^1}{W}\right] = \frac{B}{2}(W + W^1) - We$$

$$F\left[H + a\frac{W^1}{W} + W\frac{(2h2}{(Kb^2 - 2hW}\right] = \frac{B}{2}(W + W^1)$$

or $$\boxed{F = \frac{B/2\ (W + W^1}{Wx\ \frac{2h2}{Kb^2 - 2hw} + a\frac{W^1}{W} + H}}$$

The above discussion assumes:

1 Spring does not "Bottom-out".

2 Van does not touch wheel.

<u>Derivation of the Speed equation:</u>

$$F = Ma$$

or $$F\left(1 + \frac{W^1}{W}\right) = \frac{W + W^1}{g}\ \frac{v^2}{r}$$

$$v = \sqrt{\frac{\left(1 + \frac{W^1}{W}\right)Fgr}{(W + W^1)}}$$

$$v = \sqrt{\frac{Fgr}{W}}$$

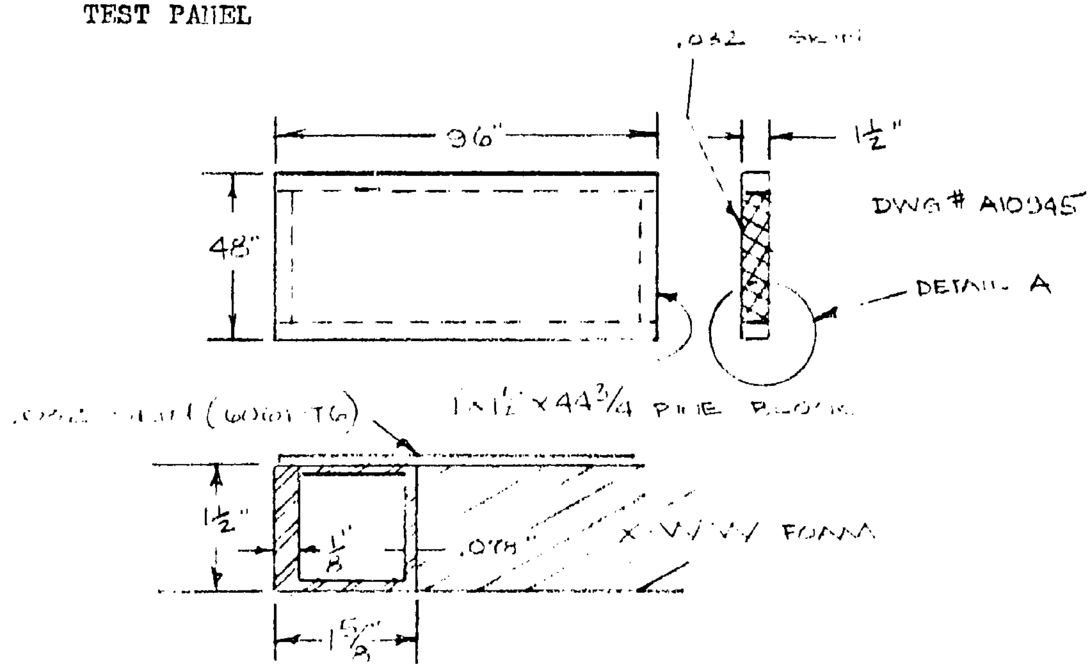
APPENDIX II

STATIC LOAD TESTS

A 4 ft. x 8 ft. test panel using 4#/ft.^{3} x - WW foam was assembled for static test load. Two separate tests were conducted, (1) .032 thick skin on one side (2) .032 skin on both sides.

TEST NO. 1

TEST PANEL



WEIGHT

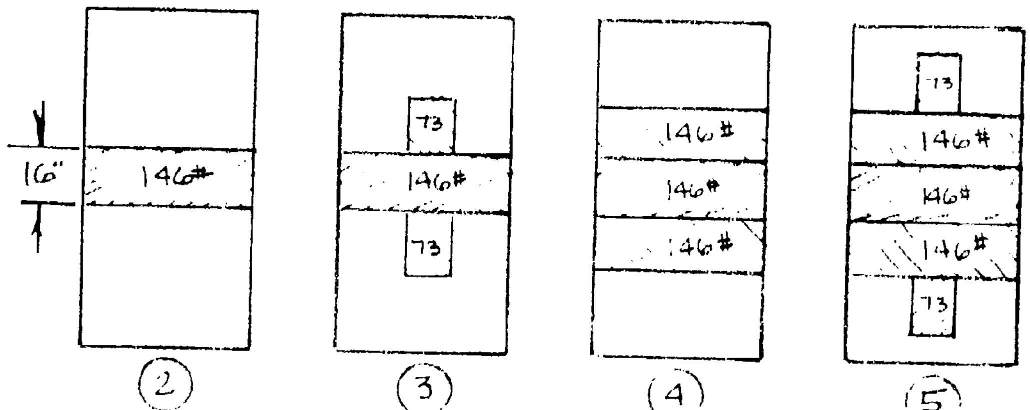
1-1/2 x 1-5/8 Tubing	9.824
.032 Skin	14.464#
Wood	1.600#
X-WW Foam	16.612
Actual Wt.	42.5 lbs.

Actual Density of 4#/ft.^{3} Foam

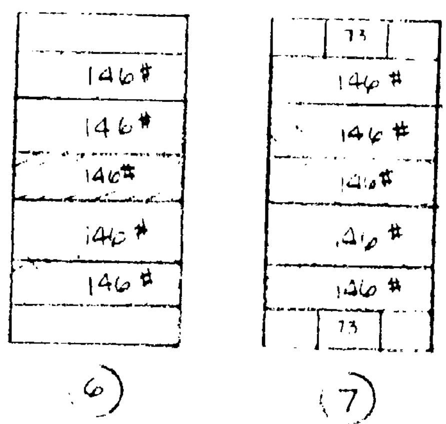
16.612/3.729 = 4.455#/ft.^{3}

TEST NO. 1 (Cont:)

Arrangement of Test Loads



TOTAL LOAD	146#	292#	438#	584#



TOTAL LOAD	730#	876#

TEST NO. 1 (Cont:)

RESULTS

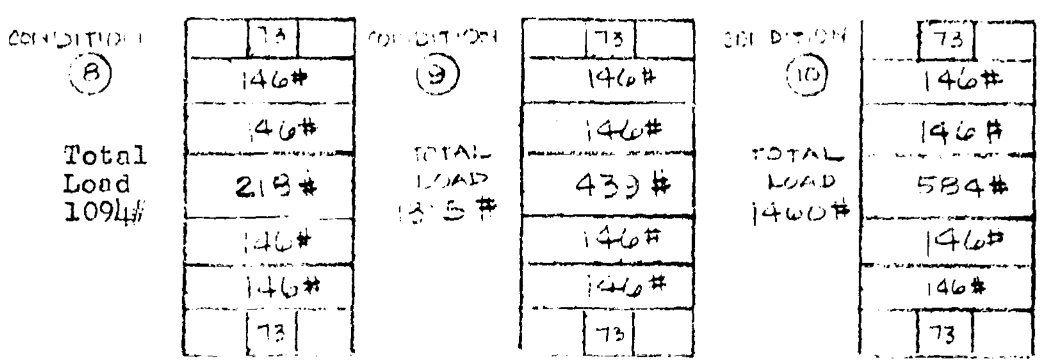
CONDITION	LOAD LBS.	DEFLECTION IN.	MAX. MOM. FT. LBS.
1	0	0	0
2	146	0.480	268
3	292	0.910	438
4	438	1.390	657
5	584	1.640	730
6	730	1.910	852
7	876	1.980	888
8	0	0.050	0

TEST NO. 2

TEST PANEL - Same Panel used for test No. 1 with .032 skin (6061-T6) bonded to opposite face.

ARRANGEMENT OF TEST LOADS

Condition 1 thru 7 same as Test #1

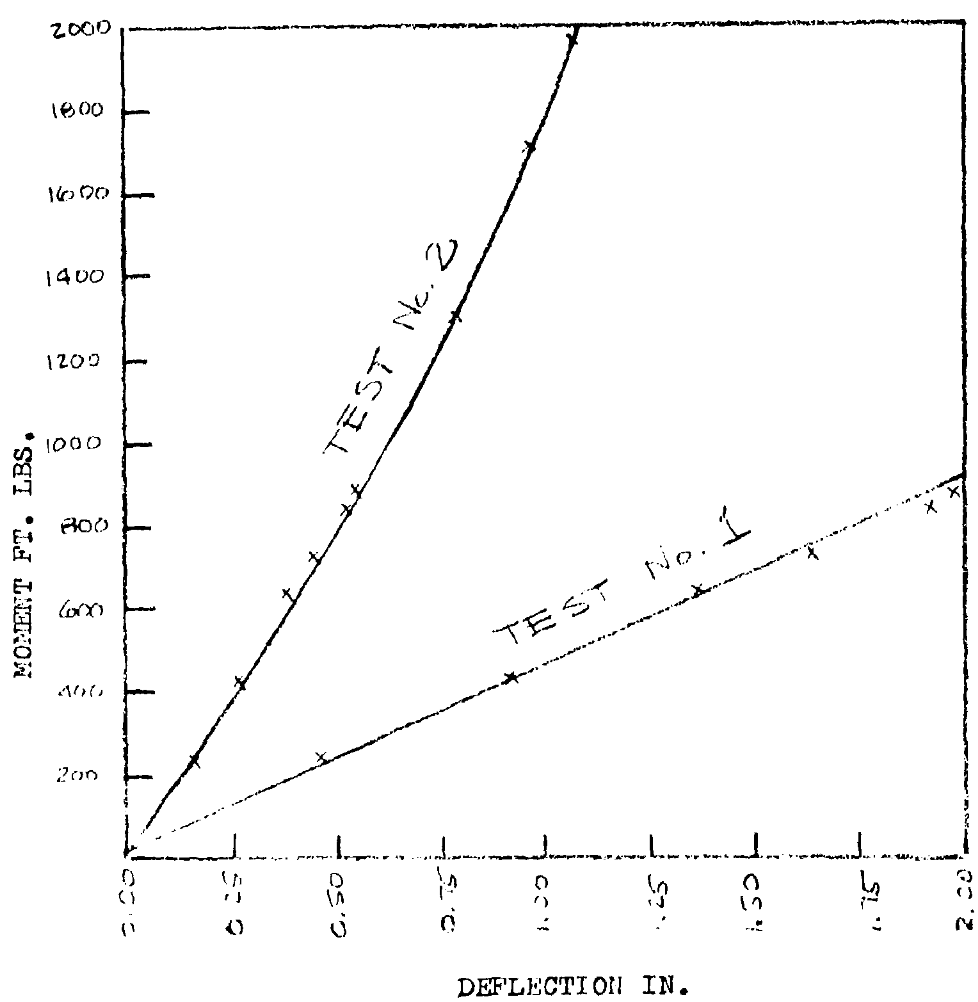


TEST NO. 2 (Cont:)

RESULTS

CONDITION	LOAD LBS.	DEFLECTION IN.	MAX MOM. FT. LBS.
1	0	0	0
2	146	0.160	268
3	292	0.260	438
4	438	0.390	657
5	584	0.460	730
6	730	0.520	852
7	876	0.560	888
8	1094	0.780	1312
9	1315	0.960	1719
10	1460	1.090	1983
11	0	1.010	0

SUMMARY OF TEST RESULTS



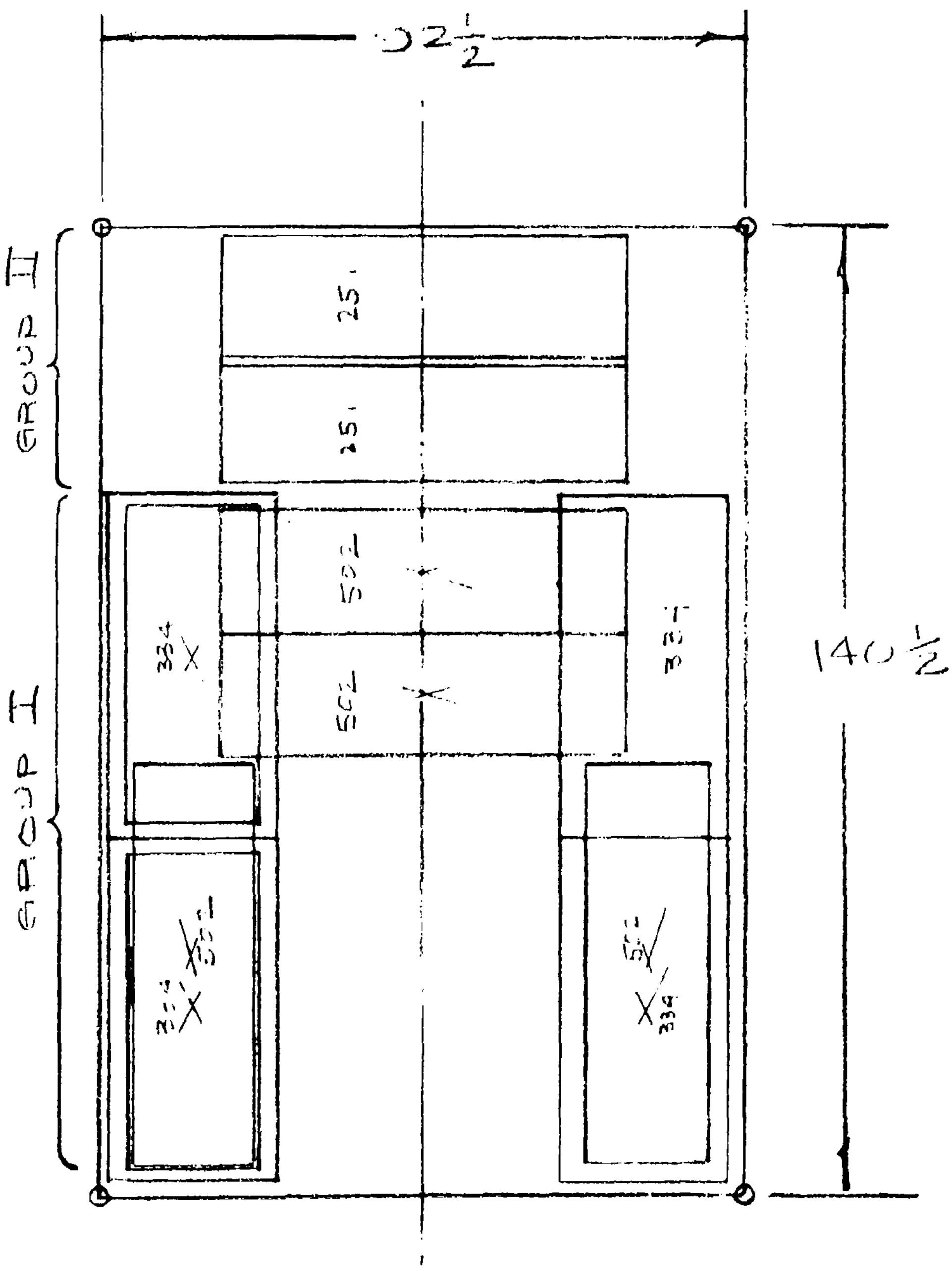
CONCLUSION

1. A panel constructed as indicated in Test No. #1 will satisfactorily take a uniform load of 27.75#/ft.^{2} with no permanent deformation.

2. A panel constructed as indicated in Test No. #2 will satisfactorily take a uniform load of 61.96#/ft.^{2} with no permanent deformation.

APPENDIX III

MOUNTING RACKS FOR TEST WEIGHTS


GROUP II
GROUP I
25
25
334
140 1/2

GROUP I

	WT	ARM	MOMENT
2 x 334	668	27	18,030
2 x 334	668	77	51,500
2 x 502	1004	34	34,150
2 x 502	1004	81	81,400
	3344		185,080

$X_1 = \frac{185,080}{3344} = 55.4$ inches

GROUP II $X_{II} =$ 121.0 inches

TOTAL

GROUP I	3344	55.4	185,080
GROUP II	502	121.0	60,800
	3846		245,880

$X = \frac{245880}{38 \times 46} = 64.0"$ inches

Try arranging Group II vertically, and see how far to move up Group I:

$502 \;|121 + 9| + 3344X_1 = 3846 \times |70 + 9|$

$3344X_1 = 303,900 - 65,300$

$X_1 = \frac{238,600}{3344} = 71.4$ inches

$(-)55.4$

Move Group I 16.0 inches fwd.

Double Check:

	WT	ARM	MOMENT
2 x 334	668	46	30,700
2 x 334	668	93	62,100
2 x 502	1004	50	50,200
2 x 502	1004	98	98,500
2 x 251	502	130	65,300
	3846		306,800

$$\bar{X} = \frac{306,800}{3846} = 80.0 \text{ inches}$$

Vertical C. G.

$$4 \times 334\ Y + 4 \times 502\ (Y + 1 + 10) + 251\ (Y + Y + 3/4 + 10)$$

$$= (4 \times 334 + 4 \times 502 + 2 \times 251) \times 32$$

$$1336\ Y + 2008\ Y + 2008\ (11) + 502\ Y + 2700 = (1336 + 2008 + 502)\ 32$$

$$3846\ Y = (3846)\ (32) - 2700 - 22,100$$

$$= \frac{98,000}{3846}$$

$$= 25.5 \text{ inches}$$

Double Check: -

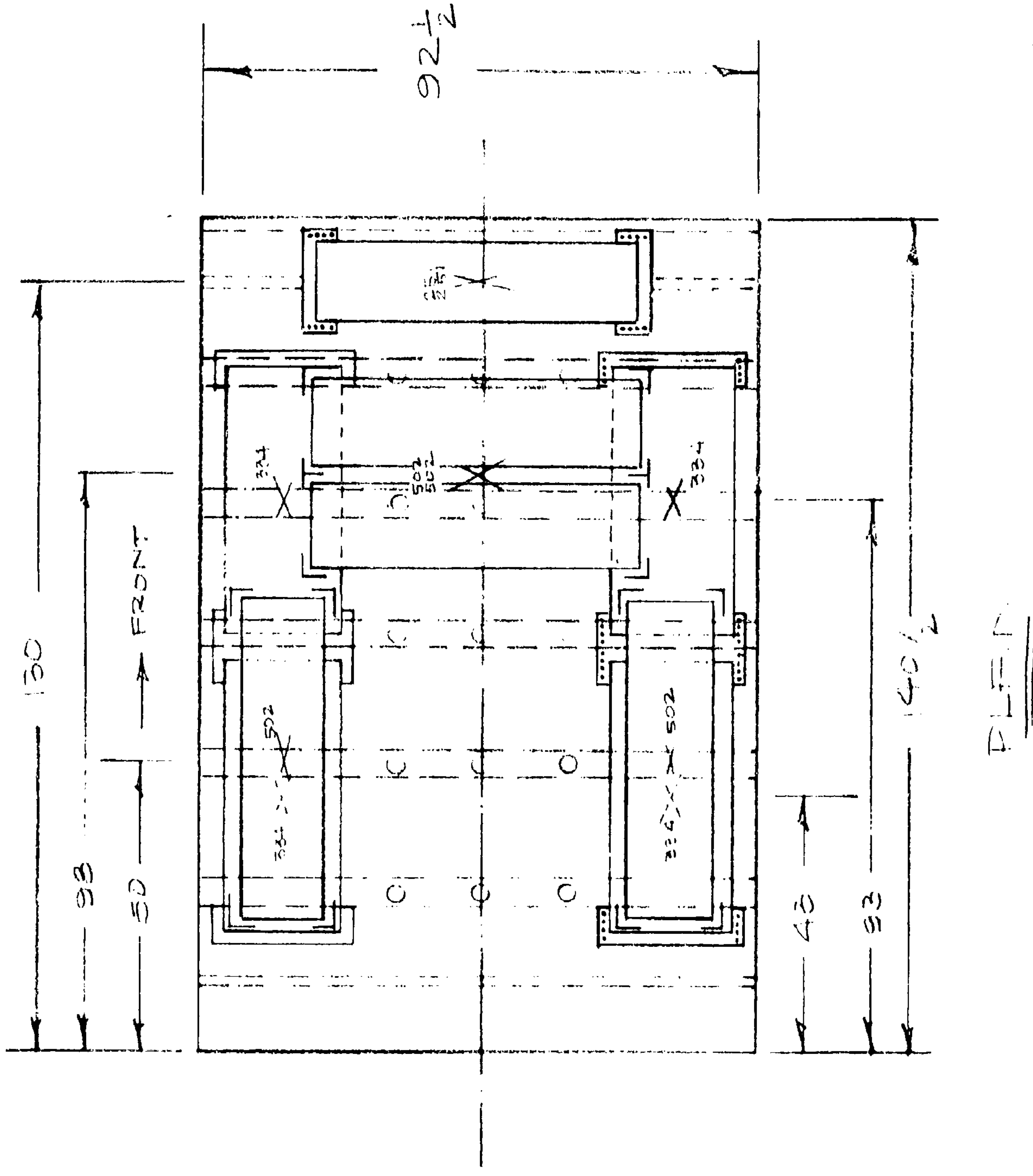
$$(4 \times 334 + 251)\ 25.5 + 4 \times 502 \times \left[25.5 + 1 + 10\right] + 251\left[25.5 + 3/4 + 10\right] = 3846 \times \bar{Y}$$

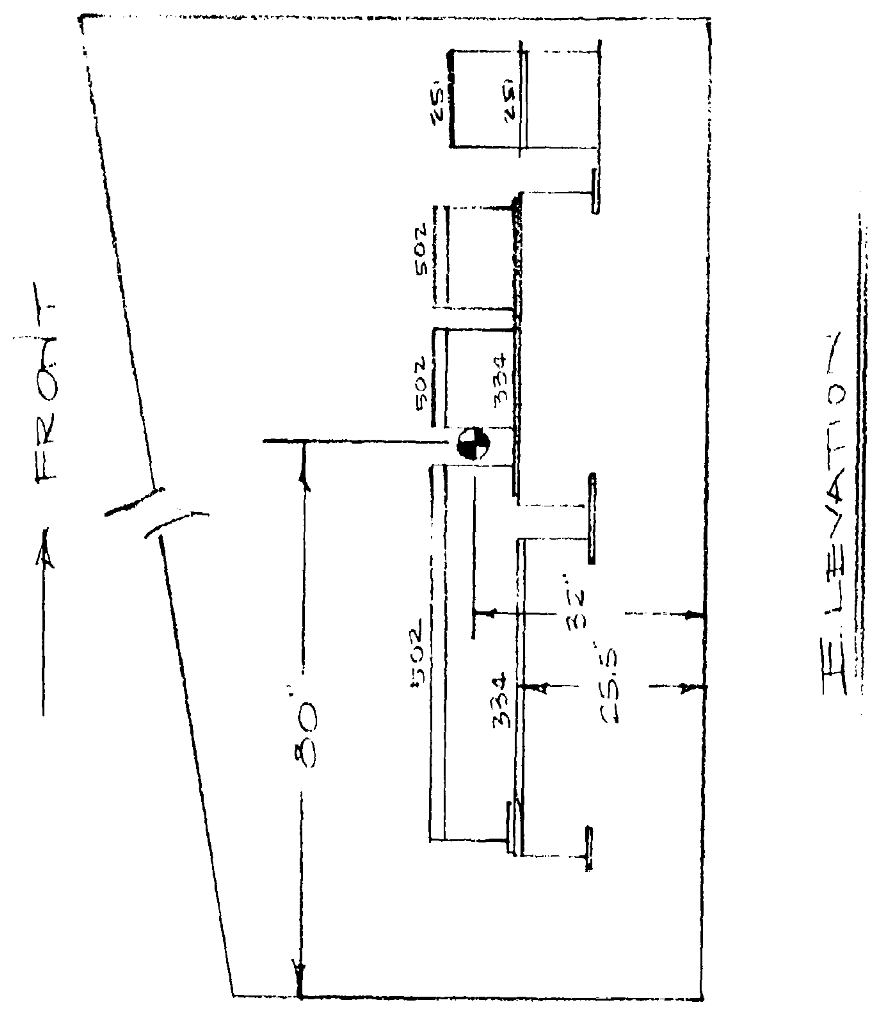
$$3846\ \bar{Y} = 1587 \times 25.5 + 2008 \times 36.5 + 251 \times 36.25$$

$$= 40{,}450 + 73{,}300 + 9100$$

$$\bar{Y} = \frac{122{,}850}{3846}$$

$\bar{Y}$ = 31.95 inches


92½
130
98
50
FRONT
160½
93
42
502
334
PLAN


FRONT
ELEVATION
80"
32"
25.5"
502
502
502
334
334
251
251

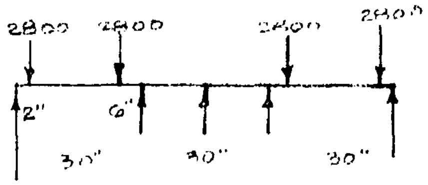
DESIGN OF SUPPORTING STRUCTURE

Try three 2 x 4's transverse @ 44" on which are mounted steel or wood table-type mounts

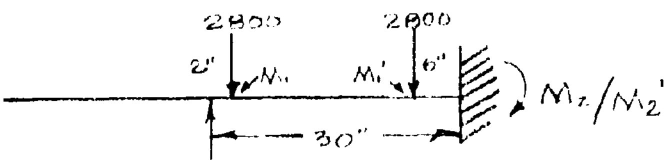
For 10-G long loading, one 2 x 4 takes:

$$\frac{10}{3} \times \left[4 \times 502 + 4 \times 334 \right]$$

$$= \frac{40}{3} \left| 836 \right| = 11{,}150 \text{ lb, loaded as follows:}$$



Call it as follows:



$$R_1 = \frac{2800\,(28)^2}{2 \times (30)^3}\ (2 + 60) = \frac{2800 \times 62 \times 784}{54{,}000}$$

$$= 2520 \text{ lb.}$$

$$M_1 = 2520 \times 2 = 5040 \text{ in-lb}$$

$$M_2 = \frac{2800 \times 2 \times 28}{2 \times 900}\ (32) = 2785 \text{ in-lb}$$

$$R_1{}^1 = \frac{2800\ (6)^2}{54{,}000}\ (84) = 157 \text{ lb}$$

$$M_1{}^1 = 157 \times 24 = 3770 \text{ in-lb}$$

$$M_2{}^1 = \frac{2800 \times 24 \times 6}{2 \times 900}\ (24 + 30) = 12{,}100 \text{ in-lb}$$

So $M \; Max = M_2 + M_2^1 = 14{,}885$ in-lb.

Best grade Douglas fir:-

<u>2 x 4</u> Weighs 1.3 lb/ft.

<u>4 x 4</u> Weighs 3.0 lb/ft. say

<u>2 x 4</u> has I max of $1.625 \times (3.25)^3 = 4.65 \text{ in}^4$

I min of $\frac{3.25\,(1.125)^3}{12} = 1.16 \text{ in}^4$

US = 2550 psi

<u>4 x 4</u> has I max of $4.65 \times 2 = 9.3$

If 2 x 4's are laid flat I max is available for 10-G loading:

$$S = \frac{MC}{I} = \frac{14{,}885 \times 1.625}{4.65} = 5200 \text{ psi}$$

<u>too high</u>

Try a 4 x 4:

$$S = \frac{5200}{2} = 2600 \text{ psi a little high}$$

<u>So try 3 x 1-1/2 x 4.1# [</u>

Z max = 1.1

Z min = .21

$$S = \frac{14{,}885}{1.1} \longrightarrow 13{,}550 \text{ psi}$$

A 1.5-G loading upward would cause a simular loading, in the ratio $\frac{1.5}{10} = .15$

So M max = $.15 \times 14{,}885 = 2235$ in-lb

$$So = \frac{M}{Z \, Min} = \frac{2235}{21} = 11{,}000 \text{ psi}$$

March 26, 1959

FIRST CONCLUSION: Use three 3 x 1-1/2 x 4.1# steel ['s laid flat.

Spearing reactions on screws:

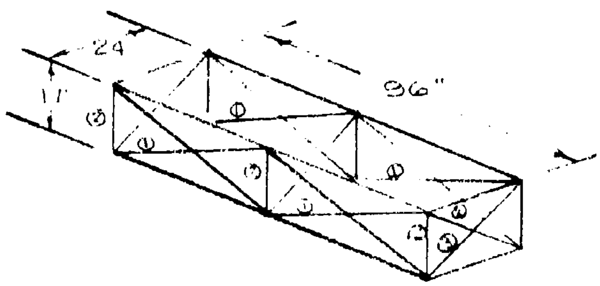
$$R_1 + R_1^{\,1} = 2520 + 157 = 2677 \text{ lb.}$$

$$R_2 + R_2^{\,2} = 5600 - 2677 = 2923 \text{ lb}$$

Davis cat. pages F-3 and F-51 says stnd. FD-1223 can take
3000 lb working load.
4000 lb limit working
4500 lb ultimate.

The above reaction would be shear on the bolt. but the 10-G loading is extreme, and assuming that ultimate in shear is .667 of ultimate in tension, then 4500 x .667 = 3000 lb.

LONGITUDINAL TRUSSES



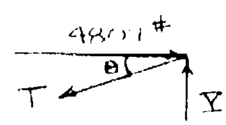
Assume members (1) carry 10-G loading in tension, each carrying 1/4 of loading on one side:

On one side: $P = [2 \times 334 + 2 \times 502 + 251]\ 10$

$= [668 + 1004 + 251] \times 10$

$= \underline{19,230}$ lbs

$\frac{P}{4} = 4,807$ lb



$T = 4807 \sec. \theta$

$\theta = \text{Tan}^{-1} \frac{17}{48} = 19.5^\circ$

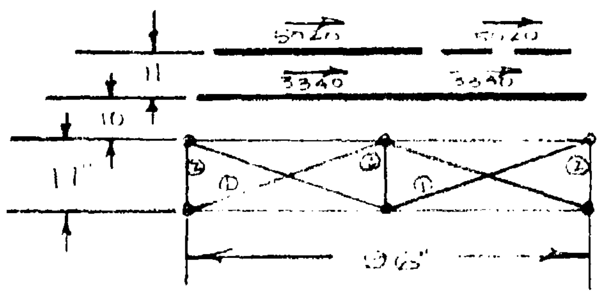
See $\Theta = \frac{1}{.9426}$

So $T = \frac{4807}{.9426} = 5100$ lb

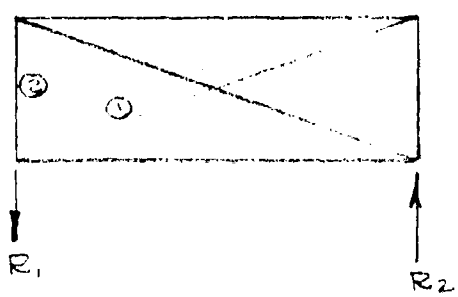
If we use 1 x 3/16 flat bar, then

$$S = \frac{P}{A} = \frac{5100}{1.0 \times .188} = 27,100 \text{ psi}$$

MEMBER (2):



Two panels carry 5020#, 38 in above floor, and 3340# 27" abov[e] floor.



$$48R_1 = \frac{5020 \times 38 + 3340 \times 27}{2}$$

$$R_1 = \frac{191,000 + 90,000}{96}$$

$$= 2930 \text{ lbs.}$$

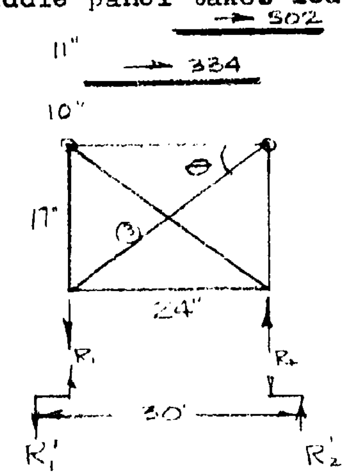
Tensile load on a bolt.

Assume member (2) is a 1 x 1 x 1/4L (1.50 #/ft.)

$A = .44 \qquad S = \frac{P}{A} = \frac{2930}{.44} = 6660$ psi

<u>Conclusion:</u> Can make frame of 1 x 1 x 1/4 L's, tied with 1 x 3/16 flat bars for diagonals in the longitudinal direction.

Size members (3) for 3.5-G side loading:
Middle panel takes heaviest load of



$[502 + 334] \times 3.5$

$= 836 \times 3.5$

$= 2930 \text{ lb}$

$\theta = \tan^{-1} \frac{17}{24} = 35^\circ$

$T_{(3)} = \frac{2930}{\cos 35} = \frac{2930}{.819} = 3580 \text{ lb}$

Try 1 x 3/16 F.B.

$S = \frac{P}{A} = \frac{3580}{.188} = 19{,}100 \text{ psi}$

Bolt load $24\, R_1 = 3.5\, [502 \times 38 + 354 \times 27]$

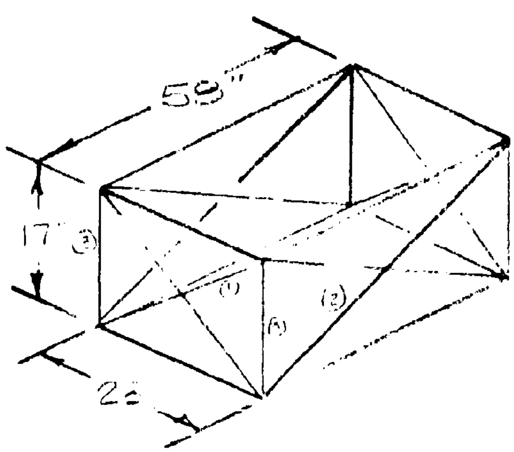
$R_1 = \frac{3.5\,[19{,}100 + 9{,}000]}{24} = 4100 \text{ lb}$

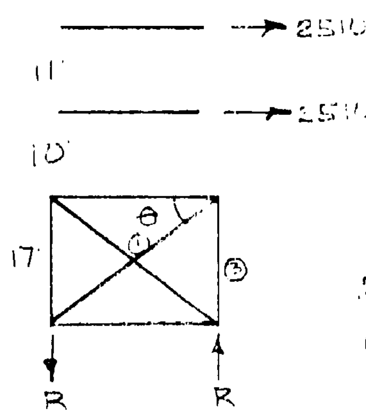
$30\, R_1 = 24 \times 4100$

$R_1 = 4100 \times 4/5 = 3280 \text{ lb}$, bolt load

STRUCTURE FOR THE 251-LB WEIGHTS (GROUP II)

10-G.





$T_{(1)} = \frac{2 \times 2510}{\cos\theta \times 2}$

$\theta = \tan^{-1} \frac{17}{23}$

$= 37^\circ$

$T_{(1)} = \frac{2510}{.7997}$

$= 3140 \text{ lb}$

March 27, 1959

Try a 1 x 1/8 F.B. for members 1 :

$$S = \frac{P}{A} = \frac{3140}{.125} = 25{,}100 \text{ psi}$$

However if this structure is tied across to the Group I structures, diagonals 1 can be eliminated.

Member 3 :

$$23R = \frac{2510}{2}\left[38 + 27\right]$$

$$R = \frac{2510 \times 65}{46} = 3550 \text{ lb}$$

and a 1 x 1 x 1/4L would be OK here.

WEIGHT OF SUPPORTING STRUCTURE

1 3 ea 3 x 1-1/2 x 4.1# @ 7.5' = 92 lb

2 Group I structure

a Legs 6 ea 1 x 1 x 1/4 x 1.5#∠ 17" long- - - - - - - - - 13.0

b Short plates 1 x 1 x 1/4 x 1.5#∠24" long - - - - - - 18.0

c Long plates 4 ea 1 x 1 x 1/4 x ∠1.5# 8' long - - - - 48.0

d Long diags 8 ea 1 x 3/16 x .64# FB 4.5' long - - - - 23.0

e Short diags 6 ea 1 x 3/16 x .64# FB 29" long - - - - 9.0

2 assemblies @ 111.0 = 222 lb

3 Group II structure

a Legs 4 ea 1 x 1 x 1/4 x 1.5#∠17" long - - - - - - - - 8.0

b Short plates 4 ea 1 x 1 x 1/4 x 1.5#∠23" long - - - 12.0

c Long plates 4 ea 1 x 1 x 1/4 x 1.5#∠58" long - - - -30.0

d Long diags 4 ea 1 x 1/8 x .43# 5' long - - - - - - - - 9.0

e Short diags 4 ea 1 x 1/8 x .43# 30" long - - - - - - - 4.0

1 assembly @ 63.0 63 lb

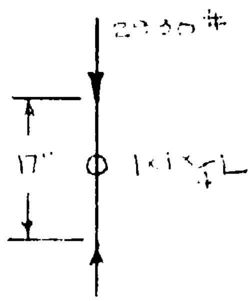
Sub-Total 377 lb

March 27, 1959

Sub	
Sub-Total	377
Miscellaneous @ 15%	57
TOTAL	434 lb.
Test Weights	3846 lb.
GROSS TEST LOAD	4280 lb.

MISC. CALCULATIONS

Re page 10 check buckling of member 2



Critical buckling load

$$P = \frac{\pi^2 EI\ (\text{min})}{\ell^2} \qquad I = Ar^2, \quad A = .44$$

$$I\ (\text{min}) = Ar^2 = .44 \times (.2)^2 = .0176$$

$$P = \frac{\pi^2 \times 30 \times 10^6 \times .0176}{17^2}$$

$$= \frac{9.9 \times 30{,}000 \times 17.6}{289}$$

$$= 18{,}000 \text{ lb} > 2930 \text{ lb.}$$

Check buckling of top plate:

$$\ell = 50" \quad p^1 = \frac{\pi^2 EI}{\ell^2}$$

$$= \frac{9.9 \times 30{,}000 \times 17.6}{2500}$$

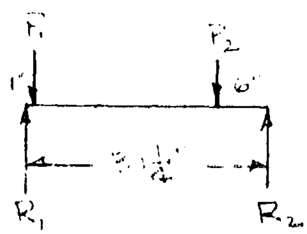
$$= 2090 \text{ lbs, buckling}$$

Actual loading:

$$P = \left[\frac{334 + 502}{2 \times 2}\right] \times 10 = \frac{8360}{4} = 2090 \text{ lbs, actual.}$$

However the presence of some fixity at ends will increase the buckling load, P^1, somewhat.

See what is needed for a floor ⊔ if it is not continuous across the floor:



$$P_1 = \left[334 \times 2/4 + 502 \times 1/4\right] \times 10$$
$$= \left[167 + 125\right] \times 10$$
$$= 2920 \text{ lbs.}$$
$$P_2 = \left[334 \times 2/4 + 502 \times 1/4 + 502 \times 1/2\right] 10$$
$$= \left[292 + 251\right] 10$$
$$= 543 \times 10$$
$$= 5430 \text{ lb.}$$

$$R_2 = \frac{5430 \times 25.25}{31.25} = 4390 \text{ lbs.}$$

$$R_1 = 2920 + 4430 - 4390$$
$$= 7400 - 4400$$
$$= 3000 \text{ lbs.}$$

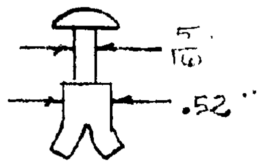
M max $= 4390 \times 6 = 26{,}300$ in-lb

Let S (all.) = 33,000 psi = YS struct. steel.

$Z = \frac{M}{S} = \frac{26.3}{33} = .797$, use 3 x 1-1/2 x 4.1⊔, Z = 1.1

Fastening loads:

The Ty-Loc will take the 4390# load, and the special screw the 3000# load



Bearing on aluminum:

$\frac{3000}{.52 \times .125}$ = 46,300 psi vs. a ys in shearing of 56,000 for 6061-T6

Shear on steel screws

$$T = \frac{3000}{.0522} = \frac{300,000}{5.22} = 57,600 \text{ psi}$$

Too high

So better use two screws at that end.

Shear on Ty-Loc FD-1223

$$= \frac{4390}{.0317} = 138,000 \text{ psi, too high}$$

So remove two of Ty-Loc plate holddown screws on ℄ of joist, and bolt channel down with two 5/16" steel cap screws.

APPENDIX IV

PRELIMINARY CALCULATION OF CENTER OF GRAVITY OF VAN

Feb. 23, 1959

VAN V-138 ( )/M

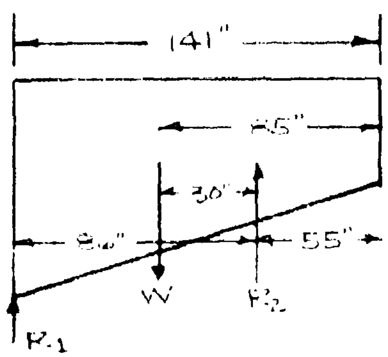
CALCULATION OF C.G. OF COVER

	WT	ARM (From Front)	MOMENT
Sides	295	80	23,600
Front	63	0	0
Rear	194	141	27,350
Roof	249	70.5	17,550
Misc.	22	85	1,870
Elec.	31	70.5	2,185
	854		72,555

$$\bar{x} = \frac{72,555}{854} = 85'' \text{ From Front}$$

Distance from front to C. G. of jack mount is 55"

$$\text{So } \Delta = 87-55 = 32''$$



W=854

$86R_1 = 30 \times 854$

$R_1 = \frac{30 \times 854}{86}$

$R_1 = 298\#$

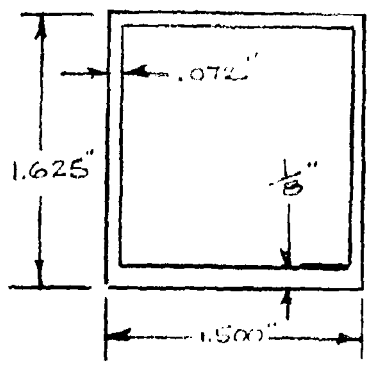
$R_2 = 556\#$

Load/forward jack = 278#

Load/rear jack = 149#

PANEL WEIGHT

Skin	4' x 8' x 144 x .032 x .098 =	14.47#
Stiffeners	1-1/2 x 1-5/8 x 1/8 x .072:	



$$A = 1.5 \times 1.625 - 1.428 \times 1.356$$
$$= 2.439 - 1.936$$
$$= .503$$
$$W = 0.503 \times 12 \times .098$$
$$= .5915 \times 16 = \qquad 9.47\#$$

Headers (pine)

$25 \frac{\text{lb}}{\text{ft.}^3} \qquad \frac{2 \times 3/4 \times 1\text{-}5/8 \times 45 \times 25}{1728} =$ 1.59#

Sub total 25.53#

Foam 4.5 x 45 x 94.5 x 1.625 = 18.00#

Actual test makes panel weigh 42.5 lbs. This would require a weight of foam of 42.50 - 25.53 = 16.97 lbs.

Hence the figure to use in calculations for weight of foam is:

$$W(\text{foam}) = 4.5 \times \frac{16.97}{18.00} = 4.24 \ \text{lb./ft.}^3$$

Use 4.5

Feb. 10, 1959

MISC. UNIT WEIGHTS

Corner extrusion	1.559 lb/ft
Tongue extrusion	.991 lb/ft
Groove extrusion	1.003 lb/ft
Door extrusion	.998 lb/ft
Roof edge extrusion	2.002 lb/ft
Stiffener 1.5 x 1.59 x .25	.827 lb/ft
Stiffener 1.5 x 1.59 x .125	.592 lb/ft
Floor stiffener	1.325 lb/ft
Inner and outer floor skin & outer skin 12 x 12 x .032 x .098 =	.452 lb/ft^2
Inner skin except floor 12 x 12 x .025 x .098 =	.353 lb/ft^2
Heat barrier material	.700 lb/ft^2
Foam insulation in sides	3.25 lb/ft^3
Foam insulation in top & bottom	4.50 lb/ft^3

FLOOR

COMPONENTS:

(1) Edge shape (4 sides)
(2) Outer skin
(3) Inner skin
(4) Wide joists
(5) Narrow joists
(6) Heat barriers
(7) Foam insulation
(8) Tapping blocks
(9) Skids
(10) Hardware

Edge shape

$$\frac{2 \times 142.75 \times 2.002}{12} = 47.55$$

$$\frac{2 \times 95 \times 2.002}{12} = \underline{31.70}$$

$$79.25 \qquad\qquad 79.25$$

Narrow floor joists	$\frac{4 \times 94.5 \times .614}{12} =$	19.30
Wide floor joists	$\frac{5 \times 94.5 \times 1.325}{12} =$	52.15
Both skins	$\frac{2 \times 92.5 \times 140.5 \times .452}{144} =$	81.70
Barriers	$\frac{(4 \times 1.5 + 5 \times 4.25)92.5 \times .7}{144} =$	12.24
Tapping blocks	$32 \times 5 \times .75 \times .875 \times .098 =$	10.30

Ty-loc plates $13 \times \left(\frac{16\pi}{4} \times .094 + 2 \times 1.44 \times .28 \right) \times \frac{40.8}{144} =$ 7.32

Skids $2 \times 136.5 \times 1.064 \times .098 =$ 28.70

Deductions

Inner floor skin $13 \times \frac{\pi (3.125)^2}{4 \times 144} \times .452 = .31$

Heat barrier $13 \times \frac{\pi (2.5)^2}{4 \times 144} \times .7 = .31$

Ty-loc screws $52 \times 5/8 \times \frac{\pi (3/8)^2}{4} \times \frac{40.8}{144} =$ 1.02

Skid screws $64 \times 5/8 \times \frac{\pi (.063)}{4} \times \frac{40.8}{144} =$ 1.00

Foam insulation

Gross area $94.5 \times 142.5 = 13{,}480 =$ 13480

Loss (a) $4 \times 94.5 \times 1.5 = 566$

(b) $5 \times 94.5 \times 4.25 = 2010$

2576 (-) 2576

$3.00 \times \frac{1}{1728} \times 1.875 \times \overline{10{,}904} =$ 35.50

328.48#

LOWER RIGHT SIDE ASSEMBLY

Outer skin

$$1/2 \times \frac{(138.25 + 2.5)\ (1 + 38.5)}{144} \times .452$$

$$= \frac{140.75 \times 39.5}{288} \times .452 \qquad 8.72$$

Inner skin

$$1/2 \times \frac{139.75\ (2 + 39.5) \times .353}{144}$$

$$= \frac{139.75 \times 41.5 \times .353}{288} \qquad 7.11$$

Light stiffeners

$$\frac{3.75 + 12.75 + 20.375 + 28}{12} \times .592$$

$$= \frac{64.875}{12} \times .592 \qquad 3.20$$

Heavy stiffeners

$$\frac{36 + 37.5}{12} \times .827$$

$$= \frac{73.5}{12} \times .827 \qquad 5.07$$

Heat barrier

$$(a)\ \frac{(64.9 + 73.5) \times 1.5}{144} \times .7 = 1.01$$

$$(b)\ \frac{\sqrt{139.75^2 + 36^2} \times 1.75}{144} \times .7 = \frac{1.23}{2.24} \qquad 2.24$$

Tongue casting

$$\frac{144.4}{12} \times .991 = \qquad 11.91$$

Corner castings

$$\frac{36.5 + 1}{12} \times 1.559 = \qquad 4.86$$

Tapping blocks

$2 \times 7 \times 2 \times 1 \times .098 = 2.8$ 2.80

Angles ($1\frac{1}{4} \times 1\frac{1}{4} \times 1/8$)

$\frac{2 \times 1.625 \times 4}{12} \times .35 =$ 0.38

Foam insulation: indirect ratio of gross areas, see page 8: $23.30 \times \frac{140.75 \times 39.5 \text{ (pg. 5)}}{140.75 \times 112 \text{ (pg.7)}} =$ 8.22

54.51#

LOWER LEFT SIDE ASSEMBLY

Similar to right except:

(a) 14.5 x 4.75 hole in both skins
(b) 35-1/2 linear inches of 1 x 2 pine (fin. dim.)

(a) $\frac{14.5 \times 4.75}{144}$ (.452 + .353)= (-) .385

(b) $\frac{1 \times 2 \times 35.5 \times 25}{1728}$ = (+) 1.030

NET DIFFERENCE (+) .645 lb

55.15#

Feb. 11, 1959

UPPER RIGHT SIDE ASSEMBLY

Outer skin	$1/2 \times \frac{140.75\left[74.75 + 37.25\right]}{144} \times .452 =$	24.75
Inner skin	$1/2 \times \frac{139.75\left[76 + 38.50\right]}{144} \times .353 =$	19.60

Stiffeners

Heavy

$$\frac{\begin{array}{r} 74.12 \\ 72.50 \\ 39.50 \\ \underline{38.50} \\ 224.62 \end{array}}{12} \times .827 =$$

Light

$$\frac{\begin{array}{r} 64 \\ 56 \\ \underline{48} \\ 168 \end{array}}{12} \times .592 = \begin{array}{r} 8.29 \\ \underline{15.50} \\ 23.79 \end{array}$$

= 23.79

Stiffener angles (3/4 x 3/4 x 1/8)

$$2\left[\frac{62}{12} + \frac{46}{12}\right] \times .20 = 3.6$$

3.60

Barriers

$$\begin{array}{r} 74.12 \\ 72.50 \\ 39.50 \\ \underline{38.50} \\ 224.62 \end{array} \times \frac{1.5}{144} \times .700 = 1638 \qquad 1.64$$

$$\begin{array}{r} 64.00 \\ 56.00 \\ \underline{48.00} \\ 168.00 \end{array} \times \frac{4}{144} \times .700 = 3265 \qquad 3.26$$

$$144.4 \times \frac{2.25}{144} \times .700 = 1552 \qquad \begin{array}{r} \underline{1.56} \\ 1.46 \end{array}$$

6.46

Groove casting $\frac{144.4}{12} \times 1.003 =$ 12.10

Corner shapes

$$\frac{\boxed{73 + 37.5}}{12} \times 1.559 = \qquad 14.34$$

Tapping blocks

(a)	= 2.80	
(b)	= 2.80	
(c) $2 \times 4.5 \times 1.625 \times .125 \times .098$	= 0.18	
	5.78	5.78

Strip blocks (maple)

$$4 \times \frac{1.91 \times 2.25 \times 14.75}{1728} \times 40 = \qquad 5.87$$

Foam insulation

$$\text{Gross } 3.25 \times 1/2 \times \frac{140 \times \boxed{77 + 40}}{1728} \times 1.875 = 28.9$$

Less (a)

$$\frac{\begin{array}{r}225\\ \underline{168}\\ 393\end{array} \times 1.5 \times 1.875}{1728} \times 3.25 = 2.08$$

(b)

$$\frac{1.875 \times 16.5^2}{1728} \times 3.25 = \quad .96$$

$$3.04 \qquad \begin{array}{r}28.9\\ \underline{3.04}\\ 25.86\end{array}$$

Net (corrected to $3 lb/ft^3$) $\frac{3}{3.25} \times 25.86$ 23.30

Extra stiffening

$$\frac{47}{12} \times .592 = \qquad 2.32$$

TOTAL 141.91 #

UPPER LEFT SIDE ASSEMBLY

Identical 141.91#

Feb. 11, 1959

ROOF PANEL ASSEMBLY

Outer sheet	$140\frac{1}{2} \times 92\frac{1}{2} \times \frac{.452}{144} = 40.9$		40.90
Inner sheet	$140 \times 92 \times \frac{.353}{144} = 31.6$		31.60
Edge shape (See page 3)			79.25
Stiffeners	$\frac{4 \times 94 \times .592}{12} = 1857$		18.57
Angles	(5/8 x 5/8 x 1/8) $4 \times 92 \times \frac{.16}{12} = 491$		4.91
Barriers	(a) $\frac{2 \times 4 \times 92}{144} \times .7 =$	3.57	
	(b) $\frac{2 \times 1.5 \times 92 \times .7}{144} =$	1.34	
		4.91	4.91

Insulation

Gross area $95 \times 143 = 13{,}600$

Loss (a) $4 \times 95 \times 1.5 =$ (-) 570 =

$3.0 \times 1.875 \times \frac{1}{1728} \times$ 13,030 — 42.50

222.64

FRONT PANEL UPPER ASSEMBLY

Outer skin: $91.75 \times 38.5 \times .452 \times \frac{1}{144}$		11.10
Inner skin: $91.75 \times 38.5 \times .353 \times \frac{1}{144}$		8.65
Stiffeners: (a) $\frac{4 \times 38.5}{12} \times .592$		7.60
(b) $\frac{1 \times 38.5}{12} \times .1.325$		4.25
Barriers (a) $\frac{4 \times 37.25 \times 1.5}{144} \times .7$		1.09
(b) $\frac{1 \times 37.25 \times 4.25}{144} \times .7$		.77
Wood framing		
$\frac{4 \times 2.625 \times 4 \times 1.25 \times 2}{1728} \times 40$	2.43	
$2.43 \times \frac{2.5}{2.625} =$	2.32	4.45
Insulation		
Gross area $88.75 \times 40 =$ 3550		
Less (a) stiffeners: $38.45 [4.25 + 4 (1.5)]$ (-)394		
Less (b) holes $2 \times 12 \times 11$ (-)264		
$3.02 \times \frac{1}{1728} \times 1.875 \times 2892 =$		9.42
		47.33
Deduction for holes in skins: $2 \times 8.5 \times 9.25 [.353 + .452] \times \frac{1}{144} =$		(-) 0.88
Note that corner shapes are omitted, since they were included in sides.		46.45

Feb. 11, 1959

FRONT PANEL LOWER ASSEMBLY

The ratio of the height of this panel, to the upper assembly, is $\frac{9.375}{9.625}$.

This assembly has only a 2" dia. hole, which we can neglect.

So take the modified net wt. of upper assembly, and add back in the pertinent deductions; and subtract the weight of the wood framing:

$47.22 \times \frac{9.375}{9.625} =$		46.00
Less wood	4.75	
Plus holes in skins		0.83
Plus insulation at holes: $264 \times 3.25 \times \frac{1}{1728} \times 1.875 =$		.86
		47.74
		-4.75
NET		42.99

TONGUE AND GROOVE ALONG FRONT

$\frac{95}{12} \times [1.003 + .991] = \frac{95}{12} [1.994] = 158$ 15.80

Tongue = (7.85#)
Groove = (7.94#)

Feb. 12, 1959

REAR PANEL UPPER ASSEMBLY

Outer skin:

(a) $30 \times 75.5 \times 2 = 4530$

(b) $1.75 \times 32.75 \times 2 = 115$

$.452 \times \frac{1}{144} \times 4645$ — 14.60

Inner skin

(a) $28.125 \times 77.0 \times 2 = 4330$

(b) $3.125 \times 32.75 \times 2 = 205$

$.353 \times \frac{1}{144} \times 4535 =$ — 11.11

Stiffeners $2 \times \frac{75.5}{12} \times 1.325$ — 16.68

Door jamb $2 \times \frac{32 + 71}{12} \times .998$ — 17.13

Barriers

(a) $2 \times \frac{75.5 \times 4.25}{144} \times .700 = 3.12$

(b) $\frac{2 \times (32 + 71)}{144} \times 1.875 \times .700 = 1.88$

(c) $\frac{2 \times 91.75 \times 1.188}{144} \times .700 = 1.06$

6.06 — 6.06

Maple framing $\frac{2 \times 1.25 \times [22 + 19]}{1728} \times 40 =$ — 2.38

Insulation

(a) $2 \times 27 \times 77 = 4160$

(b) $2 \times 3 \times 30 = 180$

$3.25 \times \frac{1}{1728} \times 1.875 \times 4240 = 14.95 \times \frac{3}{3.25}$ — 13.80

81.76

Deductions

(a) Insul at hole $\frac{11 \times 11.5 \times 1.875}{1728} \times 3.25 = .42$

(b) Skin at hole $\frac{8.5 \times 9.5}{144} [.452 + .353] = .45$

(-) .87 — (-) 0.87

80.89

Feb. 12, 1959

TONGUE & GROOVE ALONG REAR

See page #11 T(7.85) G(7.94) 15.80

LOWER CORNER CASTINGS

Volumes: (a) Bed $.5\left[6.5^2 - \frac{\pi}{16}(8.5)^2\right]$

$= .5\left[42.3 - 14.2\right]$

$= .5 \times 28.1 = 14.0 \text{ in}^3$

(b) Walls $2 \times 6.5 \times 3.75 \times .5 = 24.3$

(c) Flanges $2 \times 1/2 \times 1.5 \times 8 \times .75 = 9.0$

(d) $\left[2.5 \times 1.625 - \frac{\pi}{4}\right].75 = \underline{2.5}$

$4 \times .098 \times 49.8$ 19.51

UPPER CORNER CASTINGS

Volumes:	(a) Bed $.5\left[49 - \frac{\pi}{16}(7.5)^2\right]$	19.0
	(b) 2 sides $2 \times .5\left[7 \times 6.4 - \frac{\pi}{16}(49)\right]$	35.0
	(c) Eye $.75\left[3.5 \times 3\right]$	8.0
	(d) Hook (Est.)	$\underline{5.0}$

$4 \times .098 \times 67.0 = 26.25$

REAR LOWER PANEL

Studs	$4 \times \frac{1.25}{12} \times .592 =$	.25
Outerskin	$\frac{91.75 \times .5}{144} \times .452 =$	.14
Innerskin	$\frac{91.75 \times 2.75}{144} \times .353 =$	.62
Woodstrip	$\frac{91.75 \times 1.5}{1728} \times .25 \times 36 =$	$\underline{.72}$
		1.73

REAR DOOR

Frame (1 x 1-19/32 x 1 J)
$3.595 \times .125\ (2 \times 30 + 2 \times 69) \times .099$ = 8.81

Outer skin $\frac{70.25 \times 31.25 \times .452}{144}$ = 6.89

Inner skin $\frac{68.5 \times 29.5 \times .353}{144}$ = 4.95

Barrier strip $\frac{2\ [68.5 + 29.5]}{144} \times 1 \times .7$ = .95

Louver frame $2\ [25.5 + 19.5]\ 1.5 \times 1.88$ = 254

Front opg frame $2 \times [10.75 + 10] \times 1.5 \times 1.88$ = 117

Door latch frame $\begin{cases} [2 \times 8.5 + 8.75] \times 1.5 \times 1.88 = 73 \\ 8.75 \times 1.70 \times 2.38 = 35 \end{cases}$

$\frac{40}{1728}$ x479 11.09

Insulation

Gross vol. $68 \times 29 \times 1.875$ = 3700

Less (a) $21 \times 27 \times 1.875$ = 1063

(b) $12.0 \times 8.75 \times 1.875$ = 197

(c) $12.25 \times 11.5 \times 1.875$ = 264

1524

3700
1524
3 x2176 =
1928

3.78
36.47

Deduction on skin
$\left[\frac{9.25 \times 8.5 + 18 \times 24 + 5.75 \times 8.5}{144}\right]\ [.353 + .452] = (-)\ 3.13$ 3.13

33.34

REAR DOOR (CONT)

Louver	Small	33.34
	Large $4.5 \times \frac{24 \times 18}{9 \times 8} + E = \overset{4.5}{27 + 3}$	4.5
		30.0
Door Latch (est.)		15.0 #
		82.84

MISCELLANEOUS

Front Openings 2 ea @ 4.5		9.0
Rear opening & equipt.		
a Louver		4.5
b Damper		5.0
c Motor		10.0
Small opening, bottom left		
.25 x 18 x 8 x .1		3.6
Side doors, bottom hinged, 12¼ x 12¼		
a .025 sheet: $\frac{2 \times 12 \times 12}{144} \times .353$	= 0.7	
b Gasket	= 0.2	
c Hardware	= 1.0	
d Filler $\frac{12 \times 12 \times 2}{1728} \times 3.25$	= 0	
e Jamb: 52 x 4 x .125 x .1	= 2.6	
2 door @	5.5 =	11.0
Jack mounts: Outer front		
a Strips 2 x 2 x .375 x 48 x .098	= 7.0	
b 8 brackets @ 3#	= 24.0	
	31.0	31.0 #
		74.1

Miscellaneous (Cont) 74.1

Power Distribution Cabinet & Contents

a Back 25 x 31 x.091 x .098 = 6.9

b Cover [25 x 18 + 6 x 86] .125 x .098 = 12.0

c Contents (est.) 20.0

38.9 38.9

Lower Raceways (2 courses on 3 sides)

2 x [24 + 7] x 1.75 = 1085 108.5

Upper Raceway (Inside Cover)

1 x [24 + 7] x 1 31.0

Running lights on cover

6 x .5 = 3.0

Taillights on bottom

2 x 2 4.0

Coaming Angles (1 x 1 x 1/8)

(a) In bottom

$$\frac{2 \times 90\text{-}1/4 + 2\,[136.75 + 37]}{12} \times .28 = 12.31$$

(b) In cover

$$\frac{2\,[90.25 + 136.75 + 39 + 75]}{12} \times .28 = \underline{15.91}$$

28.22

287.7

JACKING GEAR

Jacks proper 4 @ 100 — 400.00

Swivelled casting

(a) Flange $6 \times 14 \times .5 \times .098$ $= 4.2$

(b) Body $24 + 5.5 \times .25 \times 11 \times .098$ $= 8.2$

(c) Sleeves $3 \times \frac{\pi}{4} (2.75^2 - 2^2) \times .098$ $= .8$

4 @ 13.2 — 53.0

Pins

$\frac{\pi}{4} \times 4 \times 5 \times .284 = 4.46$; 8 ea. = — 35.7

Pin Casting

(a) Plate $.375 \times 9 \times 11 =$ 37.0

(b) Sleeve $\frac{\pi}{4}$ $3.56 \times 8 =$ 22.4

(c) Ribs ½ $(8.375 \times 2) \times .375 =$ 3.1

(d) Boss $\frac{\pi}{4} (2.375)^2 \times$ ½ $=$ 2.2

4 ea x .098 = 64.7

Bolt Plate

(a) Body $7.25 \times 11.5 \times 17/32 =$ 44.4

(b) Bolt Strips $2 \times 1.125 \times 9/16 \times 6.5 =$ 8.2

.098 x 52.6 = 5.2

(c) Bolts $6 \times \frac{\pi}{4} \times$ ½ $\times 2 \times .284$ = .7

6 ea. x 5.9 — 35.5

649.6

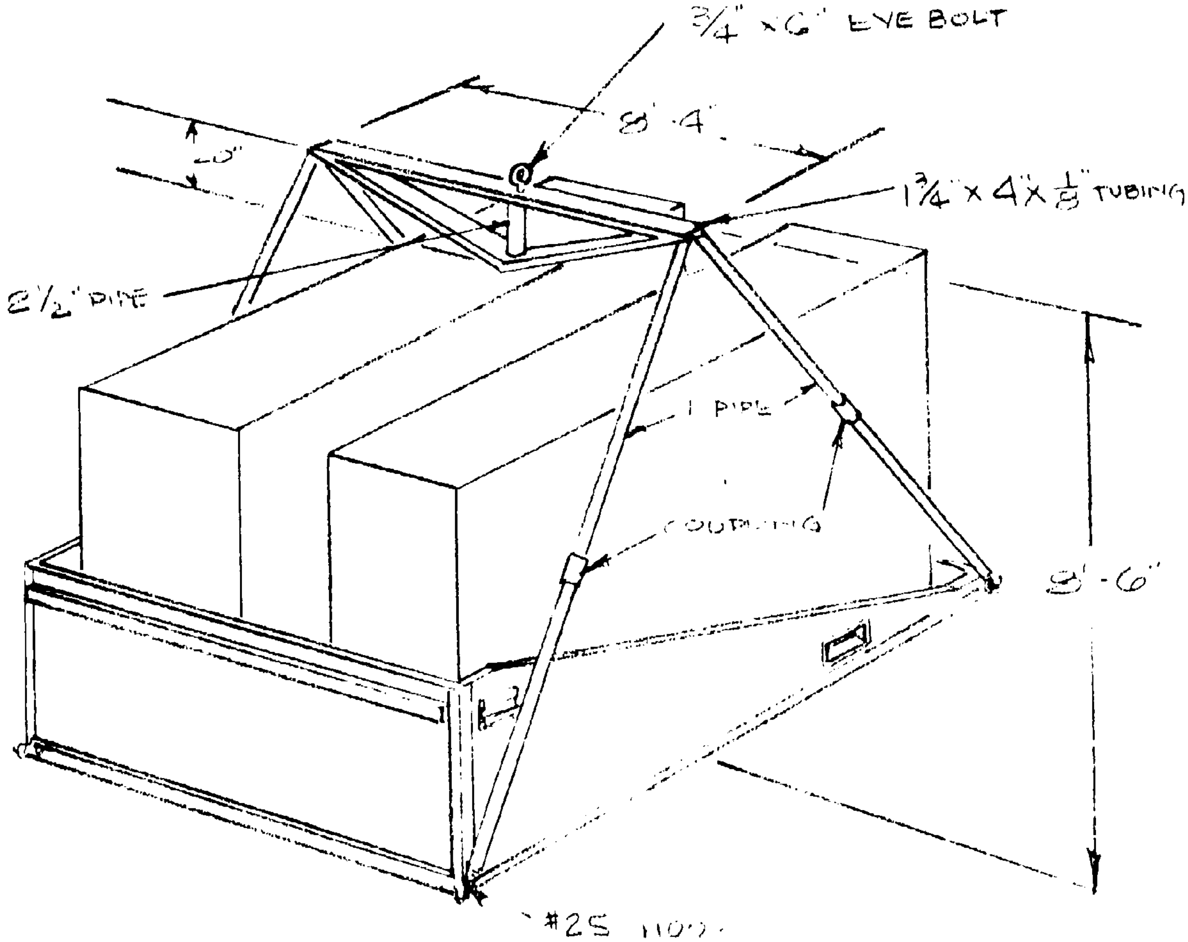
SUMMARY

PALLET		
Floor	360	
Sides	113	
Front	82	
Rear	6	
Misc (coaming, glue & mesh)	16	
Bare	577	
Electrical	147	
Gross	724	724
COVER		
Roof	249	
Sides	295	
Front	63	
Rear	194	
Misc (Coaming, glue & mesh)	22	
Bare	823	
Electrical	31	
Gross	854	854
Jacking Gear		
Complete		550
TOTAL --		2128

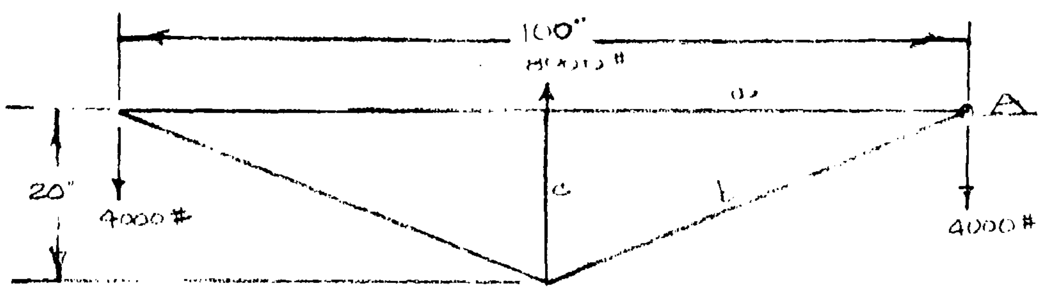
APPENDIX V

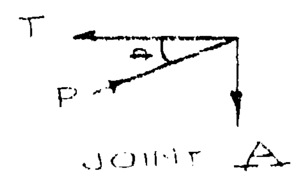
LIFTING RIG

8000# LIFT - FACTOR OF SAFETY OF 2



LIFTING RIG





$\theta = \tan^{-1} .400$

$\cos\theta = .9285$

$\sin\theta = .3714$

$P = \dfrac{4000}{.3714} = 10{,}770$ lb. comp.

$T = 10{,}770\ (.9285) = 10{,}000$ lb tens.

Assume members a and b are 4 x 1-3/4 x 1/8 tube.

$$S_b = \frac{P}{A} = \frac{10{,}770}{(8 + 3\text{-}1/4)\ .125} = \frac{10770}{11.25 \times .125} = 7650 \text{ psi compressive}$$

Investigate possible buckling of "b":

$$\ell = \sqrt{50^2 + 20^2} = \sqrt{2900} = 54''$$

$$I = \frac{4\ (1.75)^3 - 3.75\ (1.5)^3}{} = \frac{4\ (5.36) - 3.75\ (3.38)}{12} =$$

$$= \frac{21.4 - 12.7}{12} = .725 \text{ in}^3$$

Roark Table XV Case 2

$$P' = \frac{\pi^2 \times 10 \times 10^6 \times .725}{(54)^2} = \text{24,520 lb critical buckling Load.}$$

So $FS = \frac{24,520}{10,770} = 2.28$

Double check against Table XI: for 24S-T4 (YS = 48,000):

$$r = \sqrt{\frac{I}{A}}$$

$$= \sqrt{\frac{.725}{4(1.75)-3.75(1.5)}}$$

$$= \sqrt{\frac{.725}{7-5.625}}$$

$$= \sqrt{\frac{.725}{1.375}}$$

$$= \sqrt{.527}$$

$$= .725$$

So $\frac{l}{r} = \frac{54.0}{.725} = 74 > 71$

The ultimate unit load is, then

$$\frac{P}{A} = \frac{102 \times 10^6}{(74)^2} = \frac{102,000,000}{5,550}$$

$$= 18,400 \text{ psi}$$

If we assume 6063-T5 (YS = 16000)

then $\left(\frac{P}{A}\right) = \frac{18,400}{3} = 6,130$ psi vs an actual stress of 7,650 pis, which would be excessive.

However, since in our case the Table XV analysis is basically more reliable, we should accept that as the criterion.

Therefore, we can make a 4 x 1-3/4 x 1/8 box section the minimum section.

Stress on center member "c" (2-1/2" pipe)

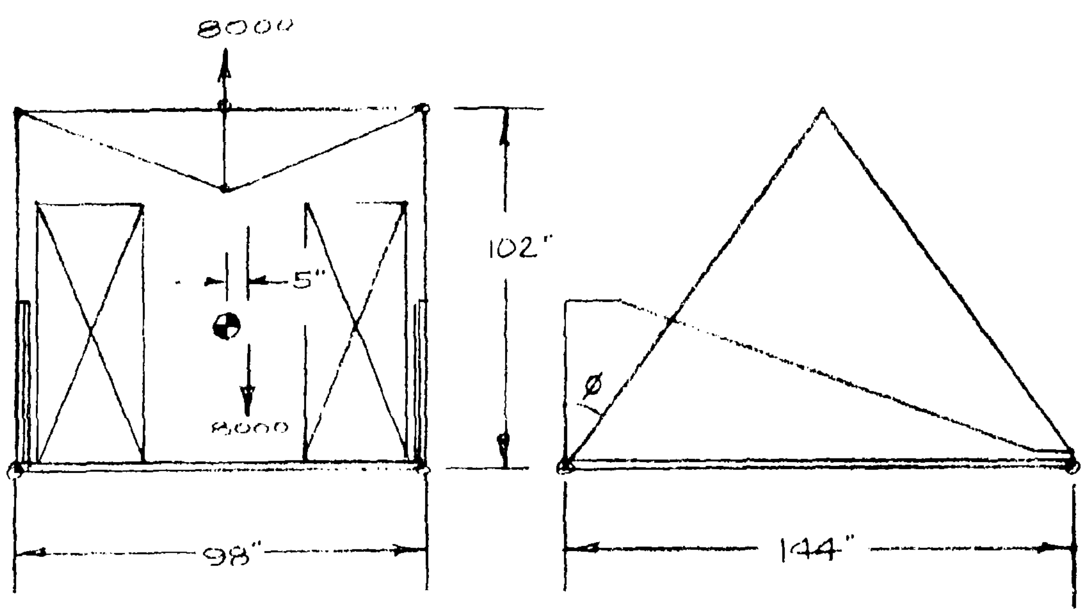
$$S = \frac{P}{A} = \frac{8000}{1.704} = 4700 \text{ psi}$$

Try 2" pipe: $S = \frac{8000}{1.075} = 7.450$ psi

$FS = \frac{16,000}{7450} = \underline{2.15}$ (assuming 6063-T5 aluminum)

So we could go down to 2" pipe

PIPE TIES



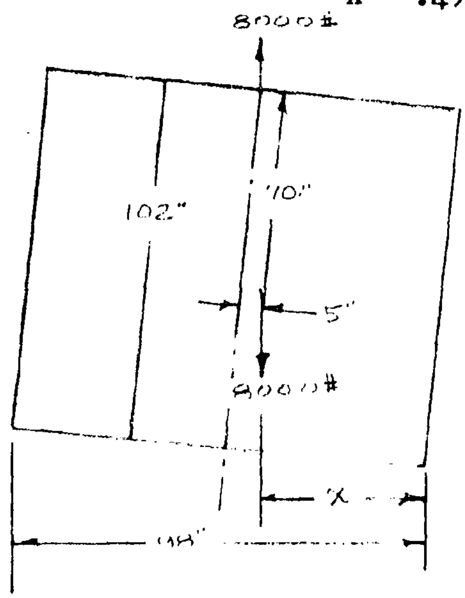
April 6, 1959

Rod Load $= \frac{8000}{4\cos\phi}$; $\phi = \tan^{-1}\frac{72}{102} = .71$

Cos. $\phi = .815$

So rod load $= \frac{8000}{4 \times .815} = 2450$ lbs.

Assume 1" pipe $S = \frac{P}{A} = \frac{2450}{.494} = 4970$ psi



Assume CG shift laterally of 5"

$X = \frac{98}{2} - \frac{102}{70} \times 5$

$= 49 - 7.3$

$= 41.7$ inches

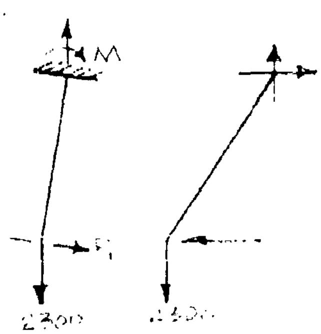
So the load to one corner on the right side is:

$R_2 = 1/2 \left[\frac{8000\,(98-41.7)}{98} \right]$

$= \frac{8000 \times 56.3}{196}$

$= 2300$ lbs.

Free body of rod:



Moment-producing force at lower end of rod is:

$P_1 = 2300 \times 5/70 = 164$ lbs.

$M = 164 \times \sqrt{72^2 + 102^2}$

$= 164 \times \sqrt{5200 + 10{,}400}$

$= 164 \times 125 = 20{,}500$ in-lb.

So stress on pipe at upper end is, then:

$$S = \frac{20,500 \times 1.3125}{.087 \times 2} = 154,600 \text{ psi},$$

<u>Too high</u>

Try 2" - 40

$$= \frac{20,500 \times 2.375}{.666 \times 2} = 34,600 \text{ psi} \quad \underline{\text{too high}}$$

But we can use 2"-40 up to a certain point:

Let $S = 17,500$, (6061-T6, SF = 2.0)

Let $M = 164\ell^1$

$$\text{So } 17,500 = \frac{164\ell^1 \times 2.375}{.666 \times 2}$$

$$\text{or } \ell^1 = \frac{17,500 \times 1.333}{164 \times 2.375}$$

$$= 60 \text{ inches}$$

Try 2-1/2-40 the rest of the way:

$$= \frac{20,500 \times 2.875}{1.53 \times 2}$$

$$= 19,300 \text{ psi}$$

$$FS = \frac{35,000}{19,300} = 1.81$$

However, if we make a non-moment-resisting connection to the yoke, a 1"-40 pipe will be enough, for the entire length.

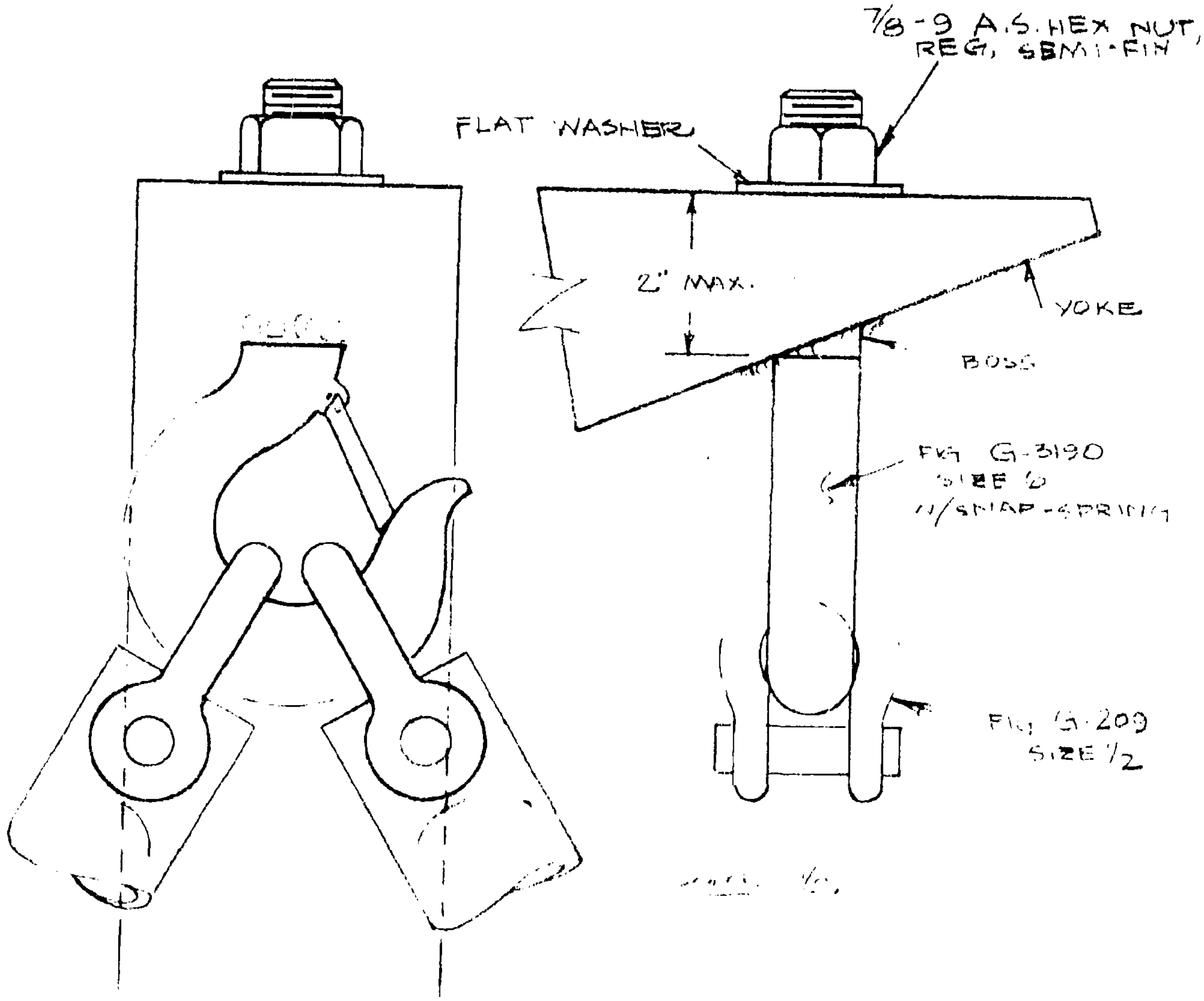
MEANS OF PIPE ATTACHMENT

Upper end:

On frame: Laughlin size 6, fig. G3190 shank safety hoist hook threaded to take a 7/8" nut.

On pipe: Laughlin size 1/2 anchor shackle, screw pin, fig. G-209 (on each pipe).

Pinch down pipe to 3/4" thickness to accommodate shackle.

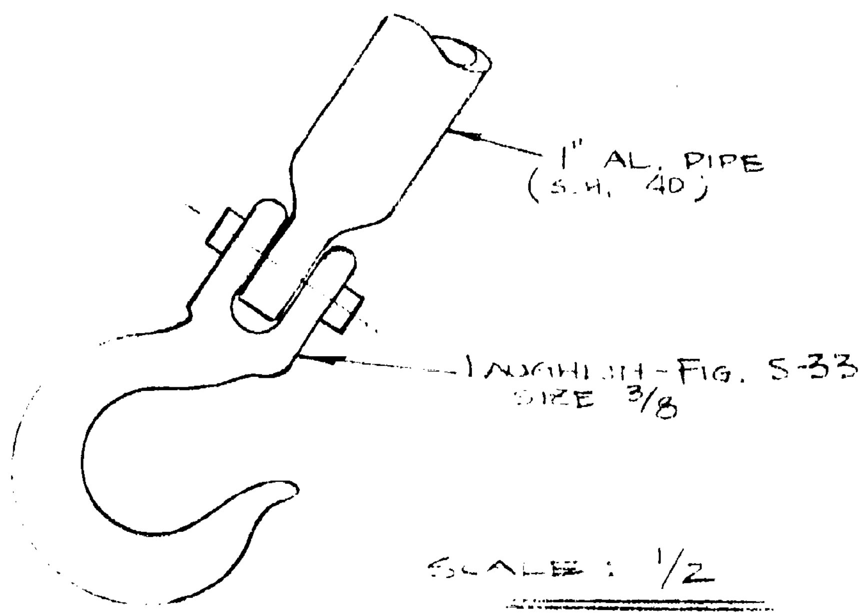


Check on bearing on aluminum:

$$S_b = \frac{P}{A} = \frac{2450}{5/8 \times 2 \times .133} = \frac{2450 \times 8}{1.33} = 14{,}700 \text{ psi}$$

Lower End:-

Use a Laughlin fig. S-331 size 3/8, attached directly to modified pipe:



Check on bearing and shear on aluminum

Pin is $\frac{15}{32}$ $S_b = \frac{P}{A} = \frac{2450}{15/32 \times 2 \times .133} = \frac{2450 \times 32}{30 \times .133}$

$$= 19{,}700 \text{ psi}$$

$$T = \frac{2450}{2 \times 5/8 \times 3/8} = \frac{2450 \times 64}{30} = 5000 \text{ psi}$$

Inasmuch as pipe is coupled at mid-length, the hook has two degrees of freedom of motion, to facilitate hooking to lower corner bracket eye.

There will be some binding of hook when load is applied, at which time pipe should be adjusted to prevent moment on its end.

Check load on threaded eye at end of yoke:

$$S = \frac{P}{A} = \frac{4000}{.4612} = 8700 \text{ psi.}$$

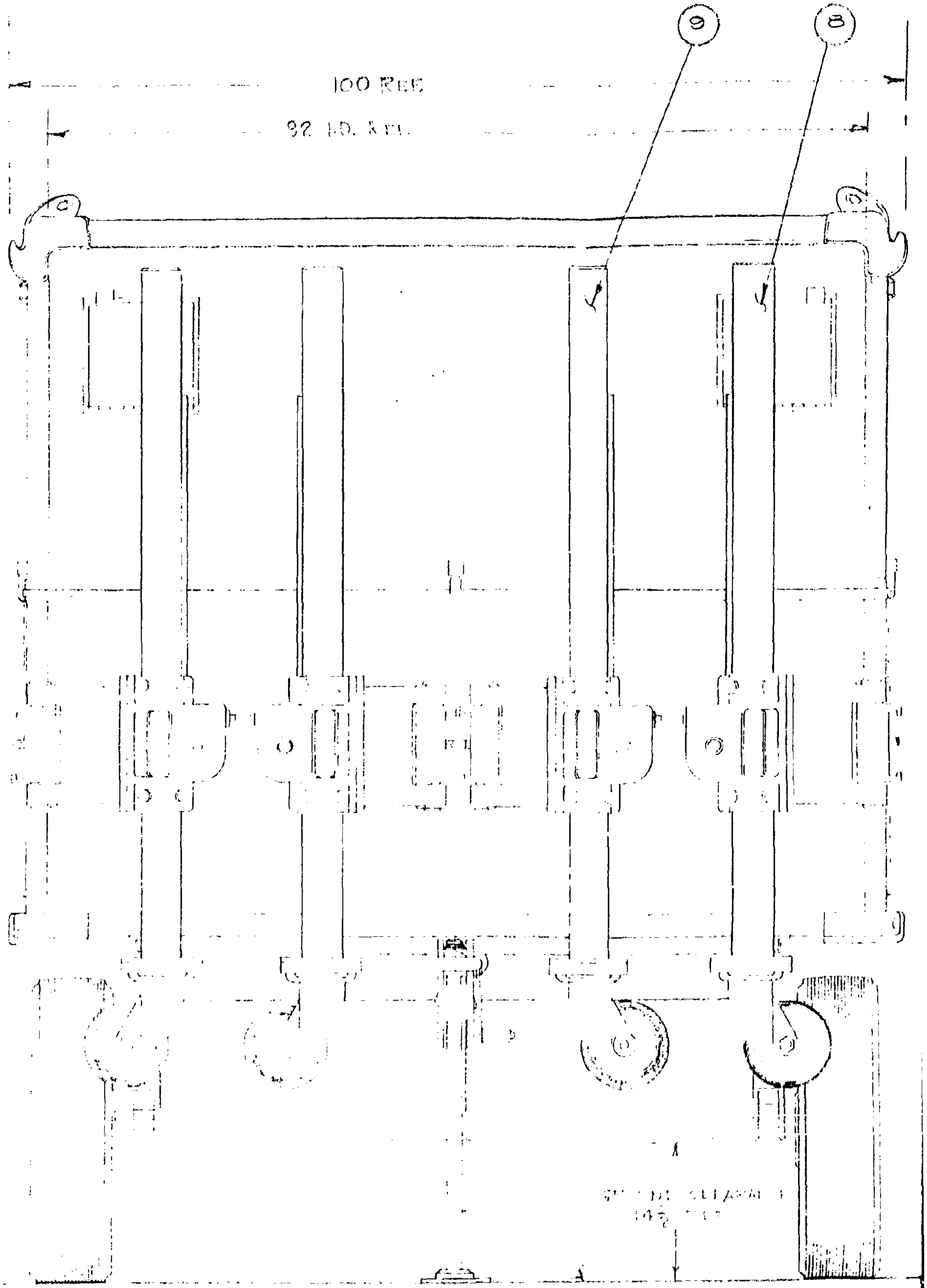
Eye at center of yoke:

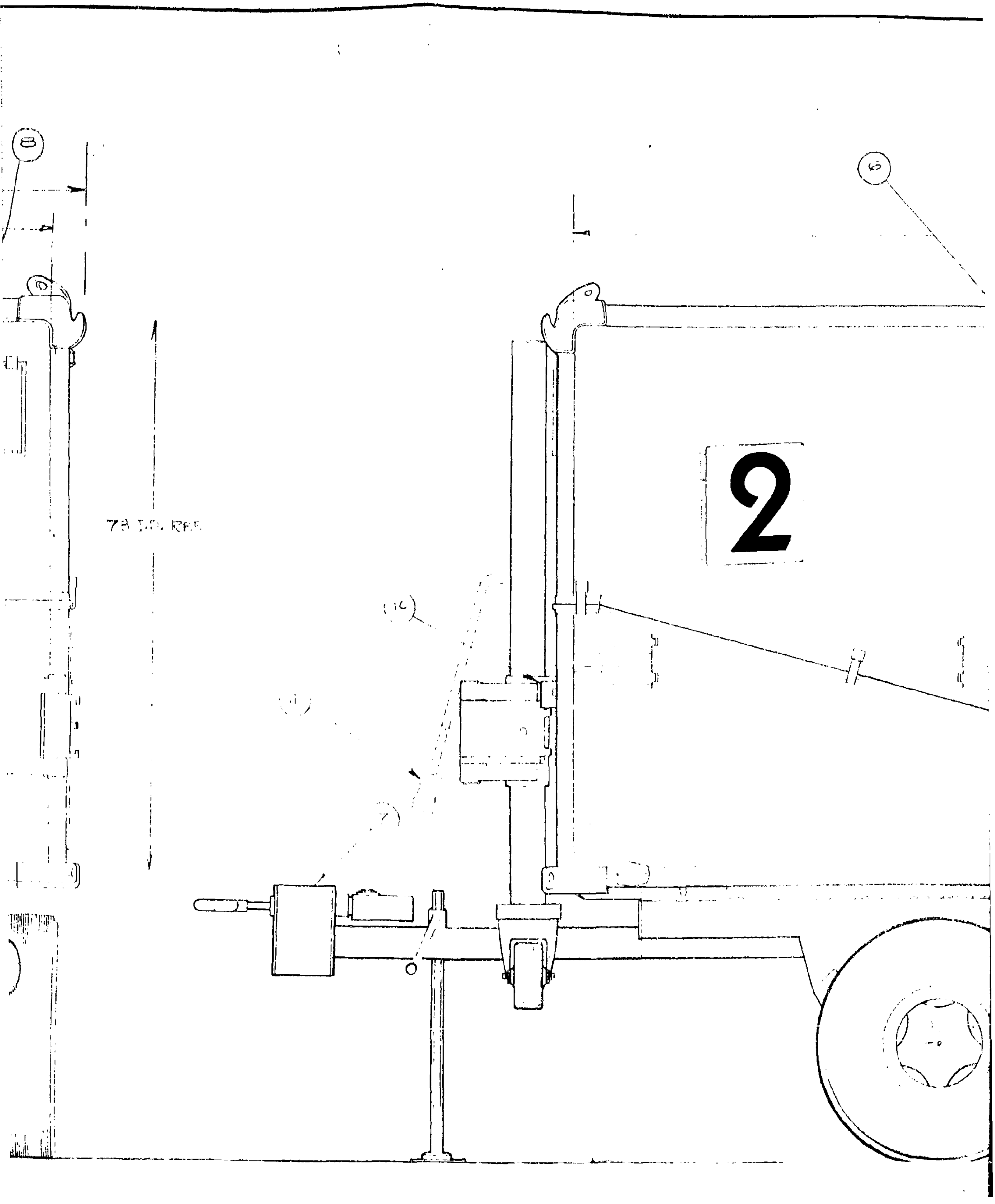
Use Laughlin G-400 size 1" (tap) and thread a 1" rod at both ends to go thru center pipe, with a nut at lower end, and flat washers at each end.

APPENDIX VI

CRAIG SYSTEMS INC. DRAWING D15547 Rev. C

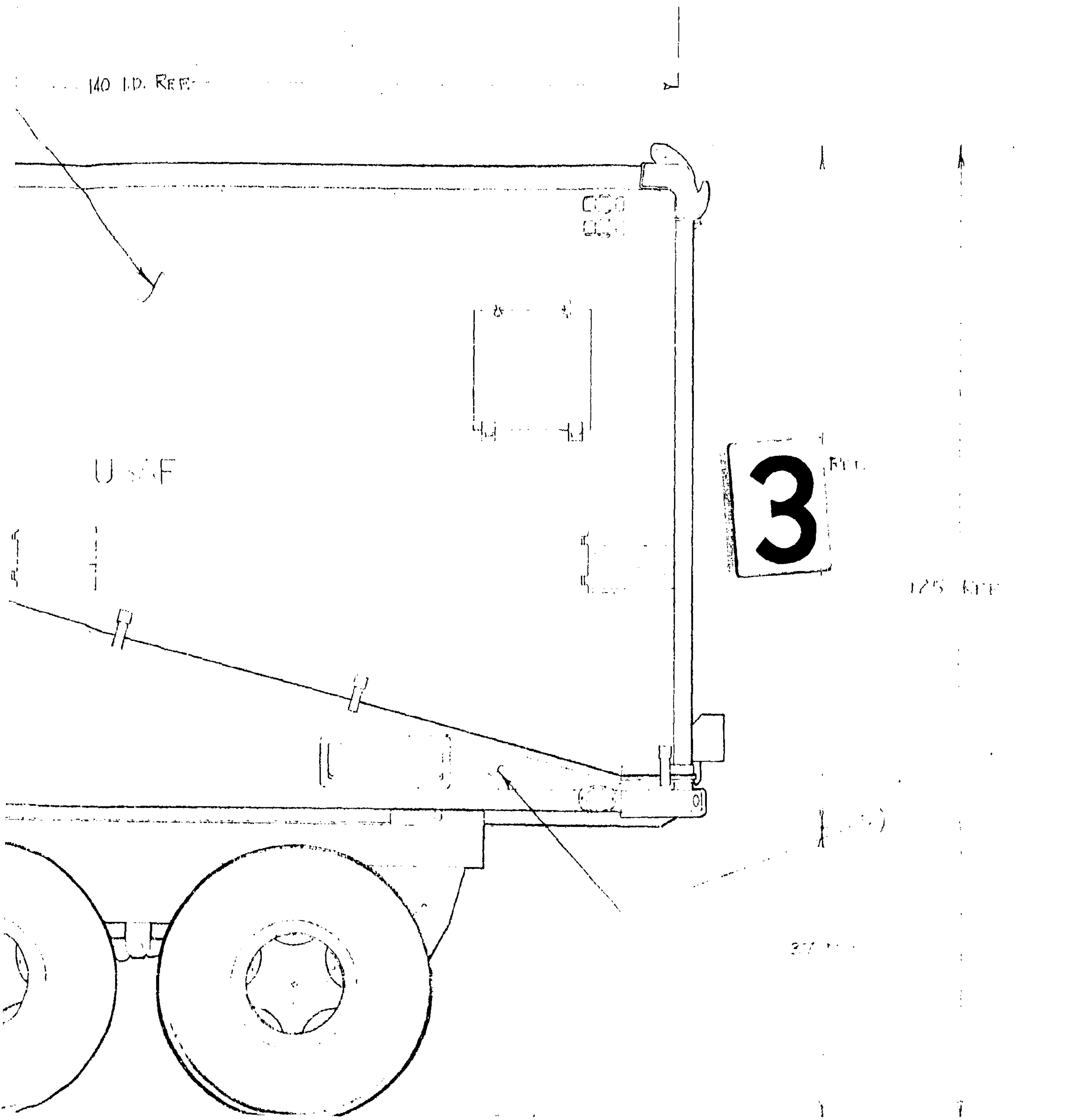
1

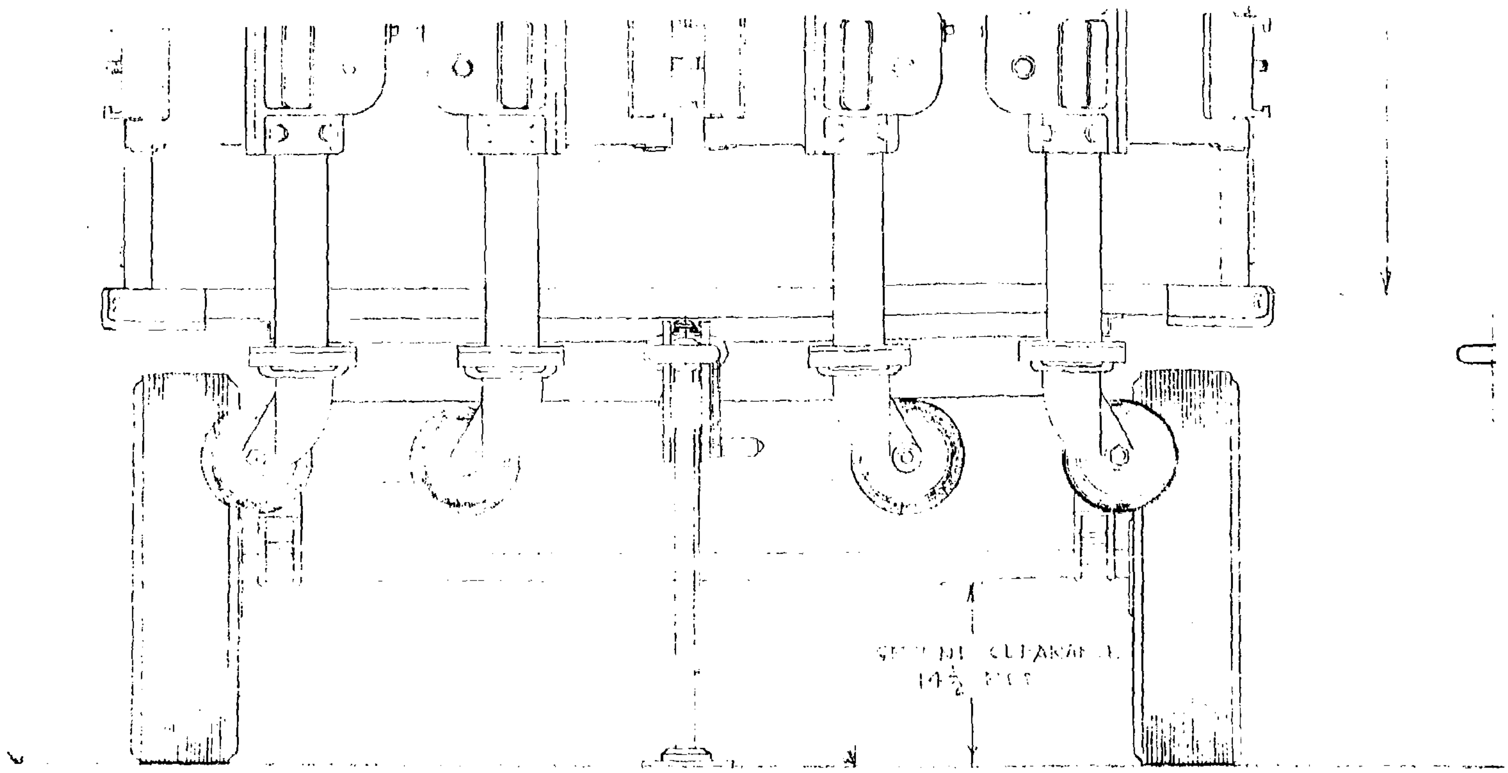




78 I.D. REF.
2

REVISIONS		ORIGINAL ISSUE SYMBOL A			
SYM	DESCRIPTION	BY	DATE	ECNN	APP'L
A	ISSUED ER 4344				
B	ADDED FIGURE 3 & 4, USAF [illegible] VAN [illegible]	[illegible]	[illegible]		[illegible]
C	ADD REF DIM'S [illegible]	[illegible]	[illegible]		





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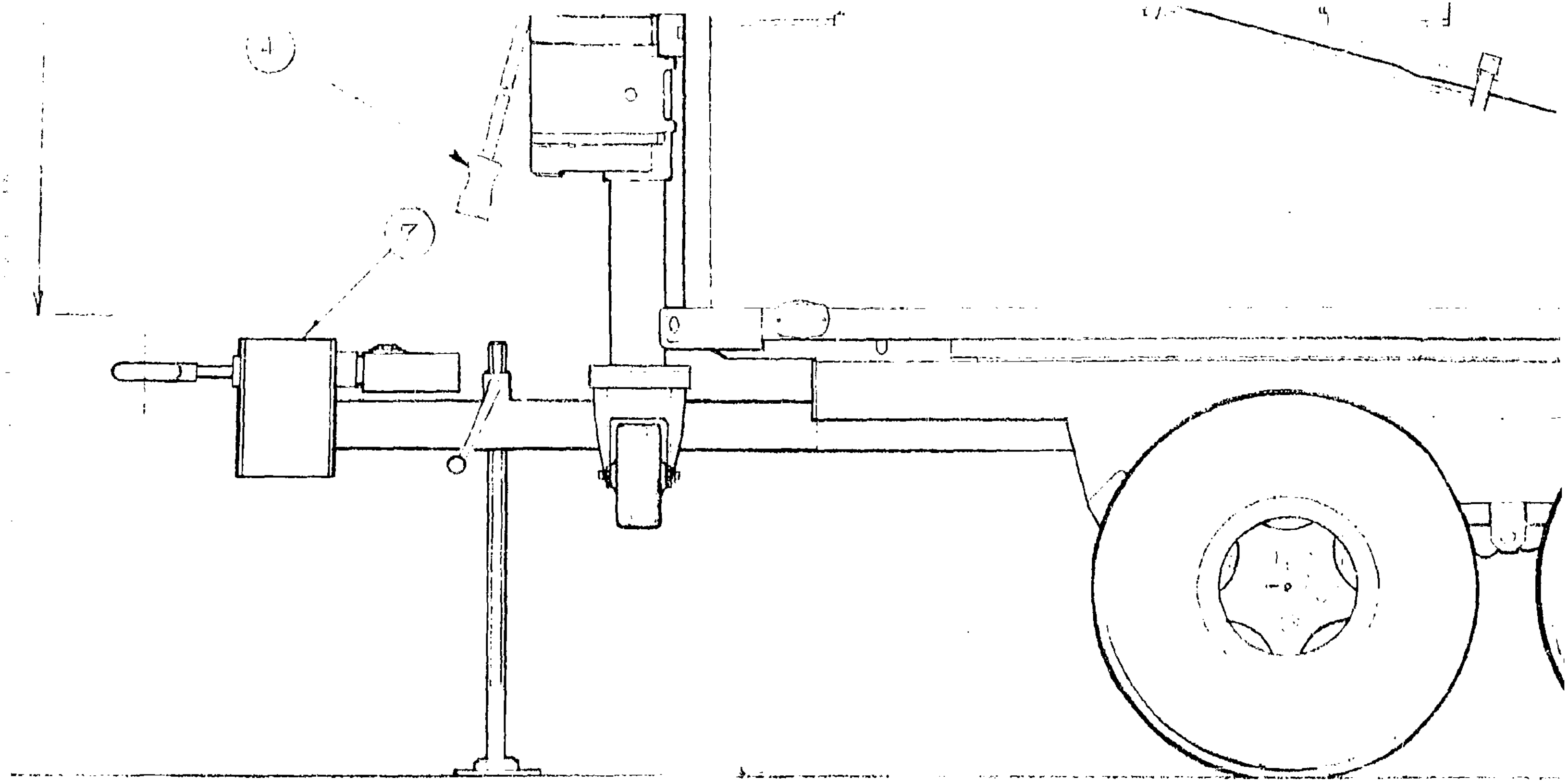


5

UNLESS OT	
TOL	
BASIC DIM	FRACT
UNDER 6	± 1/
6 TO 24 INCL	± 1/
OVER 24	± 1/

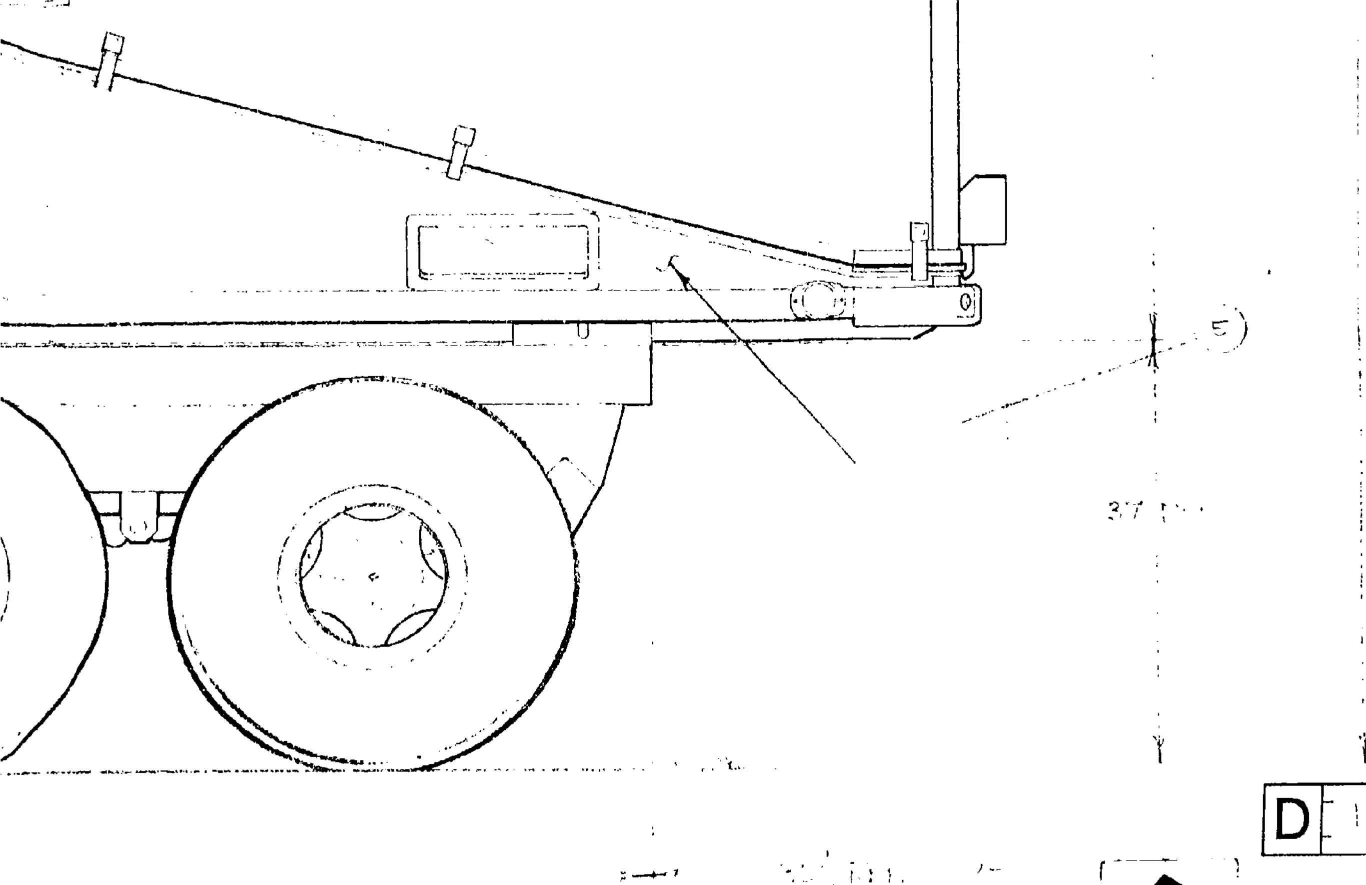
ALL DIMENSION

MATERIAL

FINISH

NEXT ASS'Y	USED ON

APPLICATION



D 15547

C

6

G2	G1	PART/DWG NUMBER	DESCRIPTION	MAT'L.	MAT'L. SPEC.	UNIT WGT.	ITEM
		[illegible]	[illegible]		·OR RE[illegible]ENCE [illegible]		10
		[illegible]	[illegible]				9
			[illegible]				8
			[illegible]		SEP [illegible] 1961		7
			[illegible]				6
							5
							4
							3
							2
			[illegible]				1

GROUP No. QTY

LIST OF MATERIAL

UNLESS OTHERWISE NOTED

TOLERANCES

BASIC DIM	FRACTIONS	DECIMALS	ANGLES
UNDER 6	± 1/64	± .005	
6 TO 24 INCL	± 1/32	± .010	± 1
OVER 24	± 1/16	± .015	

ALL DIMENSIONS INCLUDE PLATING

MATERIAL SPECIFICATION

FINISH · TEMPER

DRAFTSMAN | DATE

CHECKER

VERIFIED · M. E.

VERIFIED · E. E.

APPROVED

SCALE

Craig Systems, Inc. DANVERS, MASS.

SIZE	DRAWING NUMBER	ISSUE
D	15547	C